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Economic Potential of Base Metal and Gold Mining In Newfoundland: Assessing the Impact of Regional Development Policy Options

BRIAN MACKENZIE
MICHEL BILODEAU
MICHAEL DOGGETT

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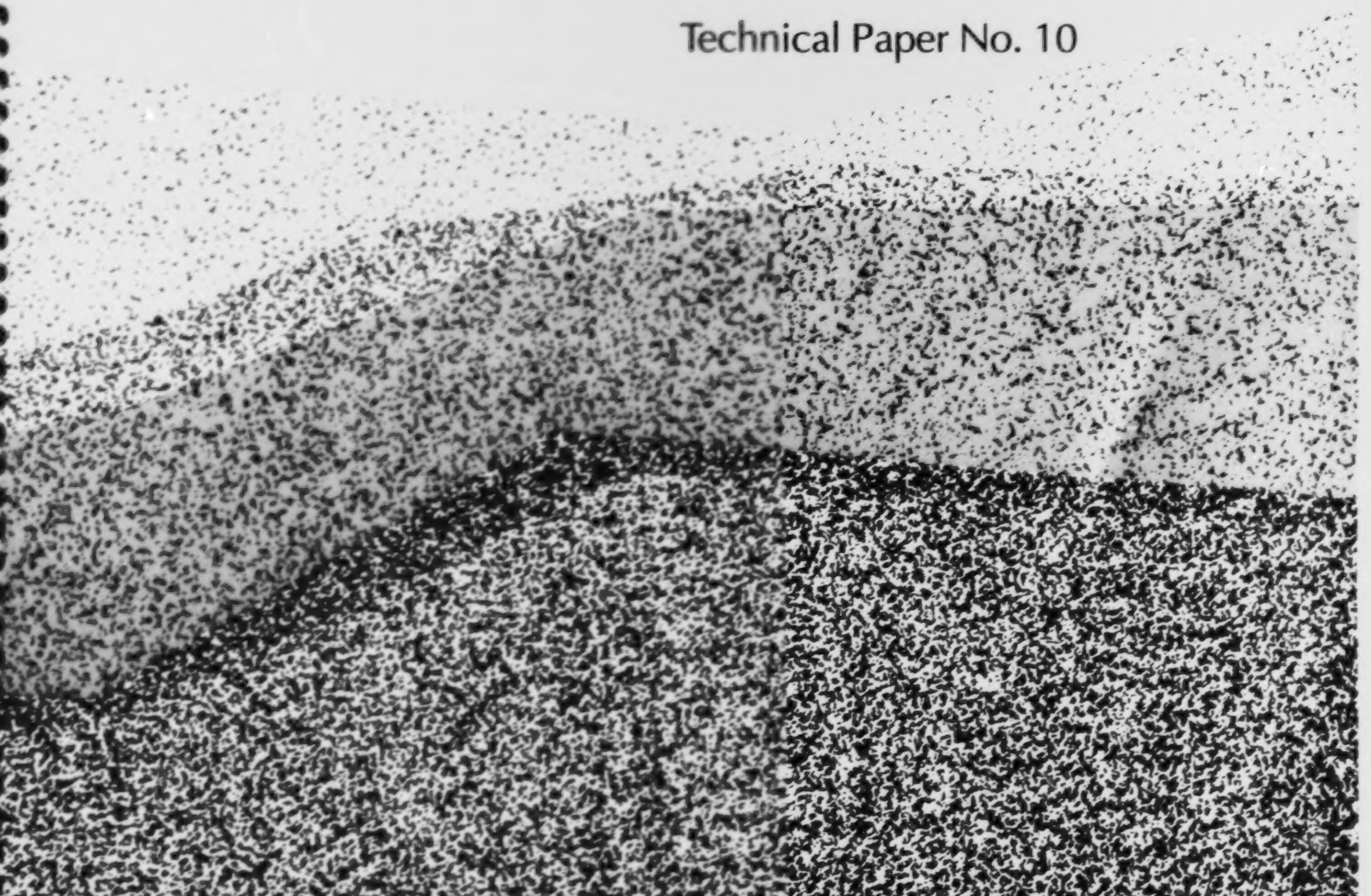

ECONOMIC POTENTIAL OF BASE METAL AND GOLD MINING IN NEWFOUNDLAND: ASSESSING THE IMPACT OF REGIONAL DEVELOPMENT POLICY OPTIONS

Brian Mackenzie
Michel Bilodeau
Michael Doggett

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PREFACE

This study was prepared under contract to the Newfoundland Department of Mines under the Canada/Newfoundland Mineral Development Agreement. It was conducted in parallel with a similar study commissioned by the Government of Ontario. Both studies have contributed to expansion and updating of the CRS Canada-wide mineral deposit data base, which is used by CRS for a wide range of research on the implications of corporate and public policies and programs affecting the mineral sector.

Views expressed are those of the authors, and do not necessarily reflect the views of CRS, its sponsors, or the Newfoundland Department of Mines.

Margot J. Wojciechowski
Centre for Resource Studies

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Brian Mackenzie
Michael Doggett
Kingston, Ontario

Michel Bilodeau
Montreal, Quebec

SUMMARY

The objective of the study is to assess the economic potential of base metal and gold mining in Newfoundland with a view to providing guidelines for government policy formulation. While the results are of an indicative nature, depending on assumptions concerning the uncertain future, they provide a meaningful overall picture of mineral supply potential in the province.

The Canada-wide data base for the appraisal includes $7.7 billion of exploration expenditures, and deposit-specific estimates for 437 base metal and gold deposits discovered during the 40-year period 1946-85 as a result of those expenditures. Within Canada, $893 million (12 percent) of the exploration was carried out in the appalachian region, resulting in the discovery of 49 (11 percent) of the significant deposits. Newfoundland itself accounts for $321 million (4 percent) of the expenditures and 18 (4 percent) of the Canada-wide total of deposits found.

The economic potential for gold and base metal mining in Newfoundland is shown to be substantial. For anticipated future conditions, long-term potential, measured from the start of mineral exploration, is characterized by an expected value of $22 million for each economic deposit discovered. Medium-term potential, measured from the start of mine development, is typified by a net present value of $71 million per economic deposit. The enhancement in potential value which occurs between exploration and development, $49 million on average for each economic deposit in this case, illustrates exploration's economic contribution to the mineral supply process.

The representative characteristics assessed for mineral exploration and mine development in Newfoundland, such as those summarized above, are broad generalizations across a wide range of experience. Several other more specific features are also highlighted:

- a high degree of variability is shown in the return characteristics of economic deposits around the composite values appraised. For example, an almost 100-fold difference in net present value is shown between the lower-decile and up-

per-decile economic deposits ($3 million and $281 million respectively);

- results for base metal and gold commodity groupings are both shown to be decidedly positive;

- the economic potential of mining in Newfoundland is found to be particularly sensitive to future metal prices. For example, none of the Newfoundland deposits evaluated would be economic at lower-limit prices. Flexibility should therefore be incorporated in government plans and policies to accommodate the resolution of price uncertainties with time.

The positive expected values assessed for base metal and gold potential in Newfoundland are found to be significantly lower than those which more broadly characterize the appalachian region and Canada. In particular, economic base metal deposits discovered in Newfoundland during the 1946-85 study period are found to be notably smaller on average than those discovered elsewhere in Canada. The missing ingredient to date appears to be one of the rare multi-billion dollar deposits. Further examination demonstrates that there is nothing unusual about the size distribution of base metal deposits in Newfoundland. The size differences assessed are mainly attributable to the difficulty of obtaining a representative weighting for extremely large deposits within the relatively small sample size of Newfoundland discoveries.

The potential value of base metal exploration in Newfoundland is shown to have made an encouraging comeback in the most recent decade analyzed (1976-85). This positive provincial trend contrasts with the marked deterioration in base metal performance which has characterized the rest of Canada since 1966-75. The economic potential of gold mining, on the other hand, appears to be improving throughout Canada. This apparent time trend is somewhat tenuous, however, because so much of the gold activity is concentrated in the 1980s.

Newfoundland's taxation policies are shown to have a substantial negative impact on investment incentive. For example, given anticipated future conditions, the expected value of exploration per economic discovery is reduced from the potential value of $22 million to $11 million after tax, and the expected net present value associated with mine development is likewise reduced from $71 million potentially to an after-tax value of $30 million.

The effects of Newfoundland's taxation system tend to be on the onerous side of the spectrum of Canadian inter-provincial assessments presented. While the overall incidence of taxation in Newfoundland is shown to be significantly lower than in British Columbia and about the same as in Quebec, Manitoba, and Saskatchewan, it is significantly higher than in Nova Scotia, New Brunswick, Ontario, Alberta, the Northwest Territories, and the Yukon. Federal corporate income tax in Newfoundland and the other Atlantic provinces is much lower than in the remaining jurisdictions because of the investment tax credit. On the other hand, the Newfoundland corporate income tax rate is relatively high, and the incidence of Newfoundland mining tax is found to rank with the Quebec system as the most burdensome in Canada. The latter result is mainly attributable to unfavourable depreciation and processing allowance rates.

The capability developed in the study to appraise the economic potential of mining in Newfoundland is also used to illustrate the comparative impact of five types of regional development policy: geologic data base development, direct exploration assistance, support for new mine development, mine production incentives, and end-of-mine assistance. While the assessments are of an exploratory nature, they suggest that geologic data base development would have the greatest impact on enhancing economic performance.

The potential values assessed in the study provide a portrait of the mineral supply process that can be applied when looking ahead to describe the distinctive economic characteristics of mineral exploration and mine development in Newfoundland for government policy analysis. More generally, the study illustrates the type of data base, evaluation procedure, and economic assessments that can be built up and used on an on-going basis. The authors suggest that the Newfoundland government consider adopting this approach to support mineral policy formulation and decision making. Several recommendations for further work are put forward for consideration.

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1. INTRODUCTION

Background

A process of information assembly and analysis is necessary to support mineral policy decisions. The basic components that must be present if the support process is to respond efficiently to policy needs are:

- an evaluation procedure to assess the potential value of mineral supply;
- an empirical data base that documents mineral exploration, development, and production activities within the jurisdiction concerned;
- on-going capability to combine the data base and the methodology to produce economic assessments;
- appraisal of the direct effects of mineral policy options on the potential value of mineral supply.

Government policy analysis normally tends to focus on a "typical" economic deposit at the mine development stage. Appropriate policy options are overlain on the typical deposit profile, and their direct economic effects are evaluated and analyzed.

This standard approach is deficient in three important respects. First, the "typical" deposit profile is, as a matter of convenience, invariably based on an actual deposit situation rather than being synthesized from the characteristics of all economic deposits. Second, the variability in economic potential among deposits is not considered. Third, the exploration activity that is a prerequisite for mine development is ignored.

For realistic government policy analysis, these three features must be examined. An average or expected deposit profile can be objectively determined only as a composite of all economic deposits. This procedure also provides the basis for appraising economic effects associated with the variability of potential among deposits. Finally, in the long term, the economics of mineral supply must be assessed from the start of exploration.

In Canada, public choices concerning regional development policy constitute an important demand for mineral economics services within government. Analysis of alternative types of policy involves evaluation of the associated public and private costs and benefits. The direct costs and benefits are assessed by appraising and comparing the impact of each policy option on the economics of mineral exploration, development, and production. Thus, an on-going capability to assess the economics of mineral supply should underlay the analysis of regional development policies.

Objective and Scope

The objective of the study is to assess the economic potential of base metal and gold supply in Newfoundland. To illustrate the application of results for government planning, the effects of mining taxation and regional development policy options on the economics of the supply process are examined.

The study methodology is based on data compiled for a large number of deposits over a relevant historical time period. Assessment of the economics of mineral supply is made by placing this experience in the context of present-day economic and technological conditions. In other words, if we were to begin to look today for the deposits which were in fact discovered during the selected historical period, how long would it take and how much would it cost to find and delineate them? Which of these discoveries would justify development? What revenues and costs would be associated with development and production of the economic deposits? In this way, we are endeavouring to use historical experience to provide the Newfoundland government with policy and planning guidelines for the future.

The assessments of base metal and gold supply are based on the 40-year period 1946-85. This time period is subdivided into four decades - 1946-55, 1956-65, 1966-75, and 1976-85 - to examine time trends in the economics of the mineral supply process.

Money values, unless otherwise specified, are expressed in constant 1987 Canadian dollars. Appraisals in the main part of the study are made on a potential value, before-tax basis, including all direct costs and revenues associated with exploration and development. The focus is on base metal and gold activities in

Newfoundland, comparing the province's performance with similar assessments for the appalachian region, and for Canada.

Appraisals are then made on an after-tax basis, considering the application of federal and Newfoundland income and mining taxation systems to the overall potential values. A comparison is made of the level and components of mining taxation in Newfoundland relative to other provinces and territories.

Finally, the capability developed to assess the economic potential of base metal and gold supply in Newfoundland is applied to evaluate and compare the impact of regional development policy options, including:

- geologic data base development;
- direct assistance for mineral exploration;
- support for new mine development;
- production stage incentives;
- assistance for mines faced with temporary or permanent closure.

These results illustrate the application of the study data base and evaluation procedure in the analysis of policy issues.

Organization of Study

An overview of the study, its main findings, and policy implications are first presented in summary form.

Chapter 2 describes the evaluation procedure developed to assess the potential value of mineral supply. The methodology provides terms of reference for assembling the study data base, and for evaluating and explaining results.

The data base for base metal and gold supply activities in Newfoundland, the appalachian region, and Canada is presented in chapter 3. The information assembled includes the estimation of total exploration expenditures, a listing of possible economic discoveries for evaluation, projections of long-term metal prices, the estimation of ore reserves and costs for individual deposits based on historical data, and the development of generalized net smelter return and deposit costing relationships.

Chapter 4 appraises the potential value of base metal and gold mining in Newfoundland. The sensitivity of economic criteria to possible variations in metal prices, the cost of capital, and the annual exploration budget is then examined in chapter 5. Newfoundland's competitive standing in the appalachian region and in Canada is appraised in chapter 6.

Chapter 7 considers the effect of mining taxation on the potential values assessed in chapter 4. A comparison is made of the incidence and components of mining taxation in Newfoundland relative to those associated with other Canadian provinces and territories.

The impact of regional development policy options is illustrated in chapter 8. The final chapter summarizes the main study findings and draws a number of conclusions.

Several matters summarized in the text are described in greater detail in the appendices. The inflation multiplier series applied in the study is shown in appendix I. Appendix II describes the method adopted for estimating base metal and gold exploration expenditures and gives more detailed breakdowns. The possible economic discoveries included in the evaluation are listed and classified in appendix III. Other discoveries considered but excluded from the evaluation are itemized in appendix IV. Appendix V describes the general revenue and cost relationships utilized. Finally, the 1987 taxation systems applied to determine the after-tax value of base metal and gold mining are outlined in appendix VI.

2. APPRAISING THE POTENTIAL VALUE OF MINING: THE METHODOLOGY

The purpose of this chapter is to describe the evaluation procedure used to assess the economic potential of base metal and gold mining in Newfoundland. The concept of "the mineral supply process" which follows provides a framework for appraising the potential value of mining for this purpose.

The Mineral Supply Process

The mineral supply process consists of a series of activities by which minerals are converted from unknown geologic resources to marketable commodities. As portrayed in figure 1 and described below, the major phases of activity in the process are (1) exploration, (2) development, and (3) production. The basic stimuli of this process are the physical occurrence of mineral deposits in nature and the demand for mineral commodities in the economy. A positive response from both exploration geologists and market researchers to particular geologic and market factors combine to guide the selection of environments for exploration.

Mineral exploration, the first phase of mineral supply, is a sequential, information-gathering process consisting of two stages: primary exploration and delineation. During the primary exploration stage, potentially favourable areas of land are selected within an environment of interest and then are subjected to a series of geological, geophysical, and geochemical tests. Successful primary exploration results in the discovery of one or more mineral occurrences, although at this stage the ultimate size and value of any occurrence is unknown.

The mineral occurrences discovered provide justification for delineation, the second stage of exploration, during which information is provided for estimating the size, grade, and physical characteristics of the discovery that are relevant to mineral or metal recovery. The objective of delineation is the identification of possible economic discoveries for evaluation. When the delineation stage has yielded enough information on a particular deposit, a decision is made about developing the deposit to production. If the characteristics of the delineated deposit warrant mine development, the mineral exploration phase is com-

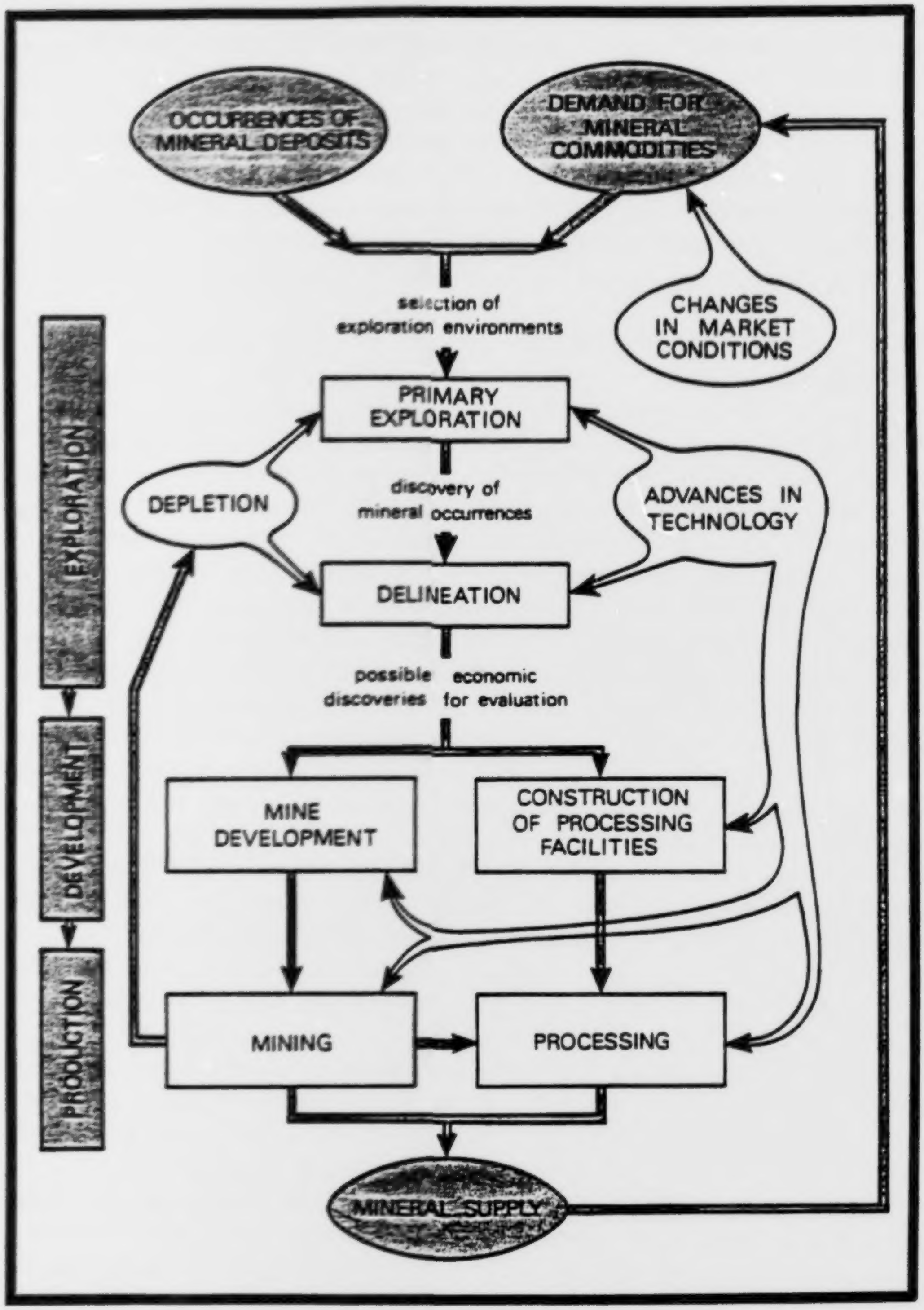
OCCURRENCES OF MINERAL DEPOSITS
DEMAND FOR MINERAL COMMODITIES
selection of exploration environments
CHANGES IN MARKET CONDITIONS
PRIMARY EXPLORATION
DEPLETION
discovery of mineral occurrences
ADVANCES IN TECHNOLOGY
DELINEATION
possible economic discoveries for evaluation
MINE DEVELOPMENT
CONSTRUCTION OF PROCESSING FACILITIES
MINING
PROCESSING
MINERAL SUPPLY
EXPLORATION
DEVELOPMENT
PRODUCTION

Figure 1. The Mineral Supply Process

pleted with what is perceived to be an economic mineral deposit as its end result.

Development, the second phase of the mineral supply process, establishes productive mining and mineral processing capacity. Since processing is required to upgrade the mine product to a metal concentrate or impure bullion that can be transported and sold, the construction of processing facilities is carried out in conjunction with mine development. A mill may be installed at the minesite, or a common processing facility may be used to treat ores from a number of mines in a region.

When a mine has been developed and related processing facilities have been constructed, the third phase - production - commences. The mining stage of production may include stripping waste for open pits, preparing stopes (underground excavations for mining), developing ore reserves, drilling, blasting, transporting materials to the processing facilities, filling mined-out stopes, and associated technical and planning services. For base metal operations, the processing stage of production usually includes crushing, grinding, flotation, drying, disposal of tailings, and the loading of concentrate products for shipment. Through processing, the ore produced from a base metal mine, which might contain 2 percent copper and 5 percent zinc, may be upgraded to produce a 25-percent copper concentrate and a 55-percent zinc concentrate, with the loss of 10 percent of the copper content and 20 percent of the zinc content in the tailings. For gold ores, processing typically comprises crushing, grinding, cyanidation, carbon-in-pulp adsorption, filtering, tailings disposal, and smelting. For example, a 6.5 gram per tonne gold ore may be treated to obtain a 98-percent gold bullion, with the loss of 6 percent of the gold content in the waste product.

The end result of the mineral supply process in the context of this study is the production of concentrate or bullion at the minesite to satisfy market demand. Market demand conditions include product transportation and smelting and refining activities as well as the sale of the metal.

The mineral supply process is dynamic in several respects. First, the market demand for mineral commodities changes with time. The factors that account for changing demand include: variations in the requirements of end uses; changes in the properties and relative costs of substitute materials; development of new product markets; and modifications in transportation, smelting, and refining conditions. Second, the physical exhaustion of mineral deposits, or depletion, is inherent in their exploitation. Thus, continual exploration is required just to sustain the existing level of mineral production. Furthermore, exploration, guided by geologic concepts and skills, is a systematic process in the long term, tending to detect first those deposits that are largest, of highest grade, closest to the surface, or closest to markets. Consequently, such deposits should, on average, be discovered, developed, and exhausted first, and deposits that are of lower grade, smaller, or harder to find come later. Thus, depletion causes the cost of mineral supply to rise over time. However, a third, offsetting, dynamic force - advances in technology - is also at work. Such advances may include more efficient and extensive exploration techniques and improved mining and mineral-processing methods. This means, for example, that the best deposits are not necessarily found first, the Kidd Creek and Hemlo discoveries being notable Canadian examples. Advances in technology act to reduce the cost of mineral supply. The combined effect of these market, depletion, and technological forces determines the economics of mineral supply over time.

As shown in figure 1, investment in the mineral supply process starts with the search for economic deposits. Thus, mineral exploration occupies the strategic up-front position in the supply process. At the beginning, all finding, development, and production activities represent controllable choices.[1] This is the only time a mining company is not committed to particular programs, projects, or mines. It should not be surprising, therefore, that corporate exploration decisions are particularly sensitive to uncertainty and change in government policy.

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[1] The premise here is that in the beginning an exploration organization has a complete range of choices. In practice, this might not be so. Small groups must constantly raise money, and large integrated companies like Noranda and Falconbridge have to support mines, mills, and smelters.

Potential Value of Mining

The potential value of mining is defined here as the difference between the revenue realized from mineral production and the costs required to realize those revenues, including an allowance for the cost of capital.[2] Since the cost of capital is deducted, this potential value represents the increase in real wealth to Newfoundland society that results from investing in mining rather than in some other economic activity.[3] Thus, potential value reflects both the quality of mineral resource endowment and the viability of the mining sector. It also measures the productive capability of mineral resources and represents what is available for sharing between industry and government before mining taxation and other public policy considerations.

Methodology for Assessing Potential Value of Mining

The potential value of mining is determined by the costs and revenues of the exploration, development, and production phases of the mineral supply process. The focal point of this process is economic mineral deposits. Consequently, potential value measures are derived from estimates of the exploration expenditures, development costs, and operating revenues and costs associated with an economic deposit.

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[2]. The cost of capital is real cost which affects the new wealth created by the mineral supply process.

[3]. The term "to Newfoundland society" is used because our intention is to allow for all the direct costs associated with mineral supply in assessing potential value, irrespective of whether these are paid for by industry or government. For example, the cost of infrastructure for new mine development paid for or provided by government is considered. We also endeavour to account for the full costs of environmental control and mine reclamation. It has not been practical at this time, however, to include the cost of government geological survey and mapping services. Also, no attention is given to the indirect income and employment effects associated with mining.

In the evaluation procedure described here, the potential value of mining is appraised on the basis of historical experience. Two assumptions are necessary if the results are to be used to plan for the future. First, deposits yet to be found must resemble, in economic terms, those that have been found to date. Second, the cost of making a future discovery must be similar to the cost in the past. However, since the mineral supply process is dynamic, we should certainly endeavour to discern time trends within the overall historical experience.

The data base for assessing the potential value of an economic deposit comprises the documentation of actual exploration, development, and production experience over a relevant historical timeframe - for example, the 1946-85 period is selected in the assessment of base metal and gold supply in Newfoundland introduced in chapter 3. For policy and planning purposes, this information is then placed in the context of current outlook conditions.

In essence, the methodology (diagrammed in figure 2) follows these steps.

1. Total exploration expenditures are estimated for the historical time period of interest.
2. Significant deposits discovered as a result of these expenditures are classified by discovery date and listed for evaluation.
3. The cash flow characteristics of the development and production phases for each of these possible economic discoveries are evaluated on the basis of current outlook conditions.
4. Discoveries that on evaluation satisfy minimum conditions of size and profitability are designated as economic deposits.
5. Cash flow characteristics of the development and production phases for all economic deposits are averaged.
6. Total exploration expenditures, which cannot in general be directly associated with the economic discoveries, are prorated across all economic deposits evaluated.
7. Estimates for the exploration phase are integrated with the average characteristics for the development and production phases to portray the time distribution of average costs and revenues for an economic deposit from the start of exploration to the end of production.

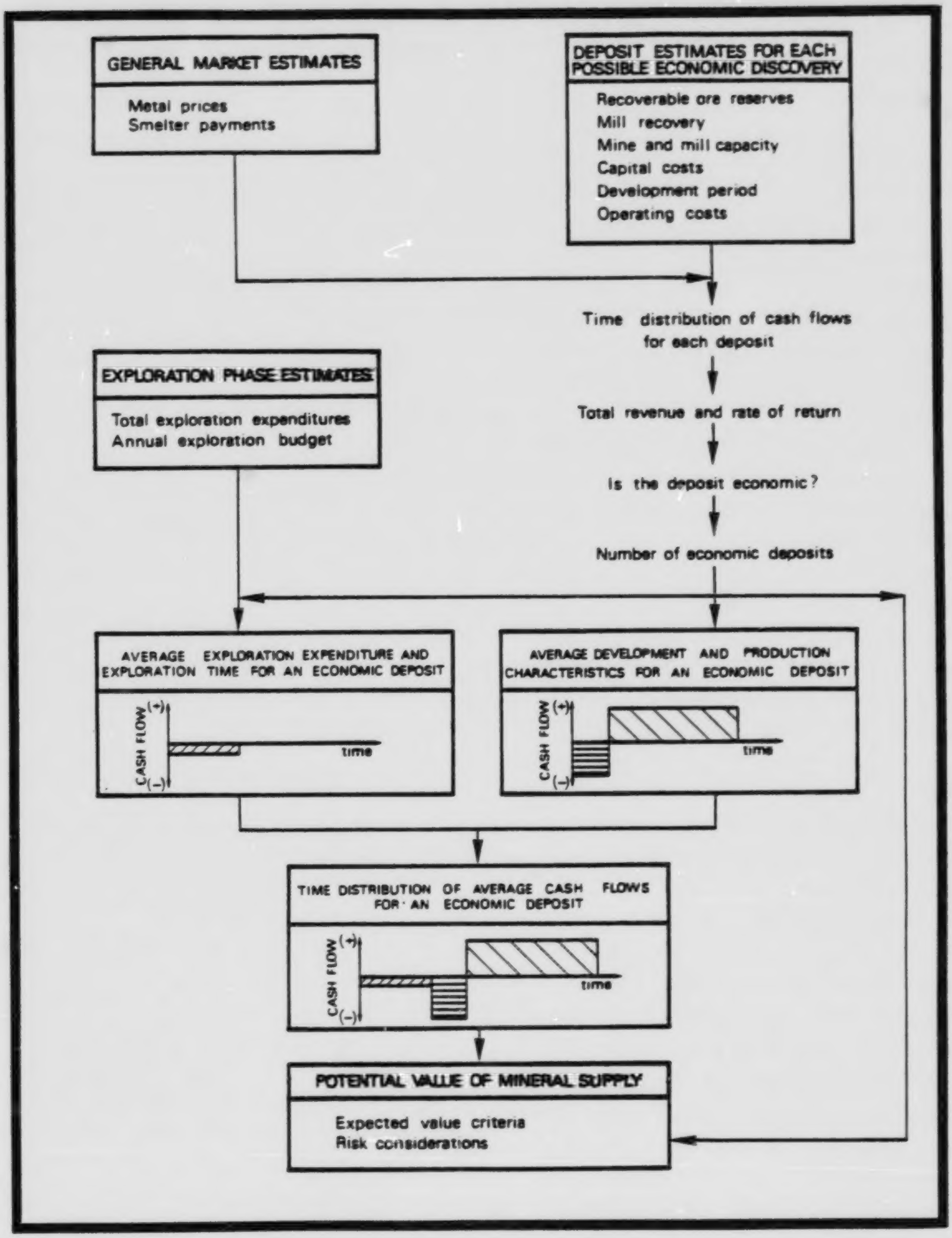
GENERAL MARKET ESTIMATES
Metal prices
Smelter payments
DEPOSIT ESTIMATES FOR EACH POSSIBLE ECONOMIC DISCOVERY
Recoverable ore reserves
Mill recovery
Mine and mill capacity
Capital costs
Development period
Operating costs
Time distribution of cash flows for each deposit
EXPLORATION PHASE ESTIMATES
Total exploration expenditures
Annual exploration budget
Total revenue and rate of return
Is the deposit economic?
Number of economic deposits
AVERAGE EXPLORATION EXPENDITURE AND EXPLORATION TIME FOR AN ECONOMIC DEPOSIT
CASH FLOW
(+)
(–)
time
AVERAGE DEVELOPMENT AND PRODUCTION CHARACTERISTICS FOR AN ECONOMIC DEPOSIT
CASH FLOW
(+)
(–)
time
TIME DISTRIBUTION OF AVERAGE CASH FLOWS FOR AN ECONOMIC DEPOSIT
CASH FLOW
(+)
(–)
time
POTENTIAL VALUE OF MINERAL SUPPLY
Expected value criteria
Risk considerations

Figure 2. Procedure for Evaluating the Potential Value of Mining

8. Several expected value criteria and risk measures, described in the following sections, are derived from the assessment. These indicators reflect the potential value of mineral supply.

More specifically, the development and production phase characteristics for each of the possible economic discoveries (step 2 above) are evaluated (step 3), as shown in figure 2, by combining general market estimates of metal prices and smelter payments with estimates for individual deposits of the following: recoverable ore reserves; mill recovery factors; a stripping ratio for open pits; mine and mill capacities; capital costs, including the working capital requirement; the length of the preproduction development period; and operating costs. These estimates, based on the actual historical record, attempt to portray how each deposit would look today if it was awaiting development. A number of measures of economic worth are derived from the resulting cash flow distributions, including the total sales revenue generated and the rate of return. Those discoveries that satisfy minimum conditions for total revenue (size) and rate of return (profitability) are deemed to be economic (step 4). The cash flow estimates for all economic deposits are then averaged (step 5), resulting in a time distribution of average cash flows for the development and production phases of the mineral supply process.

With respect to appraisal of the exploration phase (step 6), the total exploration expenditure estimate (step 1) is divided by the number of economic deposits assessed (step 4) to determine the average exploration expenditure required to find and delineate an economic deposit. To evaluate the average exploration time that would be needed to make an economic discovery, the average exploration expenditure per economic discovery is divided by an assumed most-efficient annual exploration budget rate. These estimates for the exploration phase are then integrated with the appraisals for the development and production phases.

As portrayed in figure 2, the end result of this evaluation process is an assessment of the time distribution of average cash flows for an economic deposit over the entire mineral supply process (step 7). The expected value and risk measures which are derived from these estimates to portray the before-tax, potential value characteristics of base metal and gold mining in Newfoundland (step 8) are outlined in the following sections. As part of the evaluation, the sensitivity of results to key study assumptions is examined.

Expected Value Criteria

Expected value assesses the average value that mining yields in the long term, when the successes and failures associated with a very large (theoretically infinite) number of discoveries are considered. The expected value of mining is derived from the time distribution of average cash flows for the discovery of an economic mineral deposit. This distribution is initially evaluated on a potential value basis as portrayed in figure 3. Then, to provide measures of investment incentive from the mining company's viewpoint and government revenues, the potential value assessment is converted to an after-tax basis as depicted in figure 4. The mining company decides on an after-tax basis whether it is worthwhile to invest in mineral supply. Because of time value considerations, the average cash flow characteristics must be brought to a common point in time or spread evenly over a common period of time to make a valid assessment. The following two measures of expected value - expected value per economic discovery and expected rate of return - are used in the present study.

1. Expected Value per Economic Discovery

An exploration expenditure E is required on average for the discovery and delineation of an economic deposit, yielding an average return R.

Thus:

$$EV = R - E$$

where EV = expected value per economic discovery;
R = average net return from development and production associated with the discovery of an economic mineral deposit;
E = average exploration cost required to find and delineate an economic deposit.

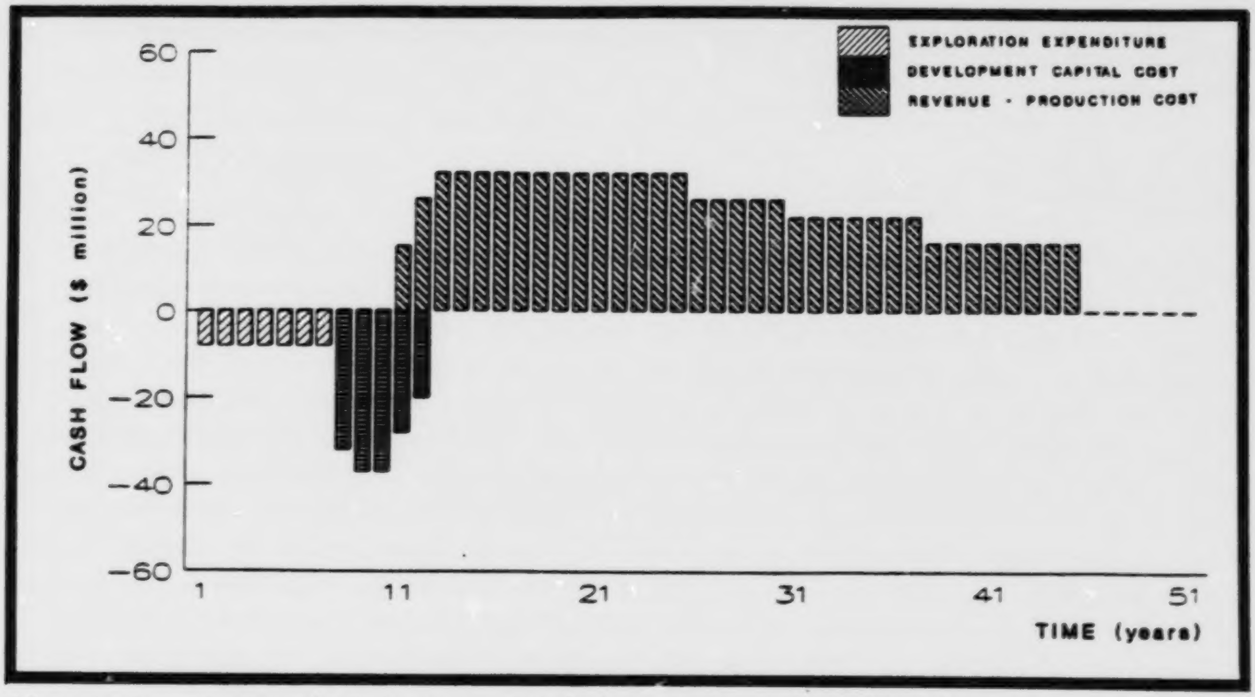

Figure 3. Potential Value of Mining: Time Distribution of Average Cash Flows for an Economic Discovery

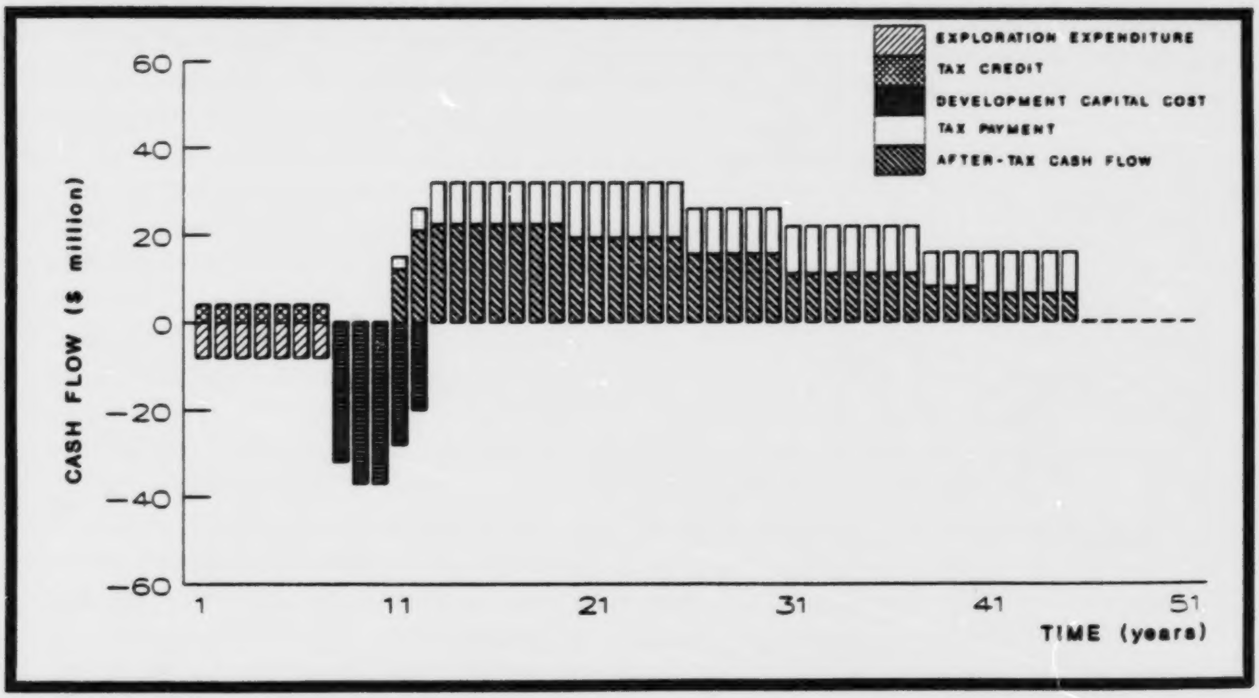

Figure 4. After-Tax Value of Mining: Time Distribution of Average Cash Flows for an Economic Discovery

To make a valid comparison, R and E are expressed as discounted values at the start of the exploration phase, using a cost-of-capital estimate for investment funds as the discount rate.

The higher the EV assessment, the more attractive exploration is perceived to be in the long term. Usually an expected value per economic discovery of greater than zero is regarded as a necessary condition for investment. A negative EV signifies that exploration is an unacceptable investment in the long term, with more money going "into the ground" in discounted terms than coming out.

The expected value per economic discovery is analogous to the criterion of net present value generally used in evaluation practice. As such, EV reflects the intrinsic economic value of mineral supply. Thus, EV comprises both size and profitability components of investment.

2. Expected Rate of Return

The expected discounted cash flow rate of return on investment may also be evaluated based on the time distribution of average cash flows for an economic deposit, depicted in figures 3 and 4. By definition, rate of return is the discount rate that equates the present value of the positive cash flows with the present value of the investment. In economic terms, rate of return is the average percentage annual return that exploration is estimated to yield over the life of the mineral supply cycle. Using this method, the minimum acceptable condition for investment is an expected rate of return equal to the cost of capital.

Expected values are assessed in this study on the basis of overall mining activity and reflect the average performance of all organizations that have undertaken mining investment in Newfoundland. Obviously, there are benefits to be gained from the application of superior skills and selectivity. In geological environments characterized by unacceptable overall expected values, the selection of opportunities of above-average merit is a necessary condition for long-term success. This can only result from the application of superior skills, developed within a mining company over time through continued exposure to particular environments of interest.

Risk Considerations

The four types of risk outlined below are associated with realizing the expected values offered by the mineral supply process.

1. Market risk, reflecting the sensitivity of mining economics to the high level of uncertainty associated with forecasts of short-term fluctuations and long-term trends in mineral commodity prices, including exchange rate uncertainty.
2. Project risk, caused by the uncertainty associated with estimating ore reserves, recovery and dilution factors, capital expenditures, and operating costs for specific economic deposits.
3. Geologic risk, related to the uncertainty of the return, given an economic discovery, which arises because of the variability in size, grade, and other geologic parameters among economic deposits.
4. Discovery risk, the low probability - typically a 1 to 2 percent chance - of an economic mineral deposit, given the discovery of a mineral occurrence.[4] The implications of discovery risk for exploration planning is of particular importance.

These risks, individually and collectively, present challenges to the long-term profit, survival, and growth of mining organizations. Inevitably, actual results are very much different than those indicated on the basis of expected values. To be realistic, an understanding of these risks needs to be incorporated in the formulation of government mineral policy.

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[4]. The discovery of a mineral occurrence, as portrayed in figure 1, is the successful outcome of primary exploration or, in other words, a technical or geologic success. More specifically, the discovery of a mineral occurrence can be defined as indications of mineralization of potentially economic grades across mineable widths obtained by drilling. Adopting this definition, empirical studies of mineral exploration in Canada and Australia show that there is typically a .01 to .02 probability of discovering an economic deposit each time a mineral occurrence is found.

The market risk arises from uncertainties in the materials market for mineral commodities. The economics of mineral supply is sensitive to anticipated prices. Flexibility is required in mineral policy and planning to contend with unexpected changes in market conditions. Thus, the assessments of economic potential for base metal and gold mining in Newfoundland made in the present study consider a wide range of possible long-term metal prices.

The project risk associated with the estimation of ore reserves, mining and processing costs for a particular mineral deposit is critical when an investment decision is being taken concerning mine development. However, in generalizing across many deposit situations to appraise the economics of mineral supply for broad regions of interest, as we are doing here, the individual project risks are not as important.

The geologic risk may be measured by cumulative probability distributions of return parameters such as total revenue, rate of return, and net present value for all economic discoveries. With reference to figure 5, cumulative probability distributions are constructed in the following manner. For each return parameter, individual deposit values are ordered from the lowest to the highest. These values are then plotted against cumulative probability, the fraction of the total number of economic deposits which have values less than or equal to each value. When the highest value is reached, the cumulative probability equals unity. Key statistics can then be derived as shown in figure 5 to represent the overall distribution. For example, a cumulative probability of 0.10 specifies the lower-decile value; i.e. 10 percent of the economic deposits have values less than or equal to the lower decile and 90 percent have higher values. The median (or middle) deposit value is designated by a 0.50 cumulative probability. The mean deposit value is the average of all deposit values. The distribution of returns around the mean value is the economic reflection of the geologic variability which exists among economic deposits.

Because the discovery risk is so high, the application of limited exploration funds does not ensure the realization of expected values. Thus, exploration resources are often expended without success. The organizational risk assocated with exploration success can be quantified by applying the classical problem of the gambler's ruin. The practical implication of dis-

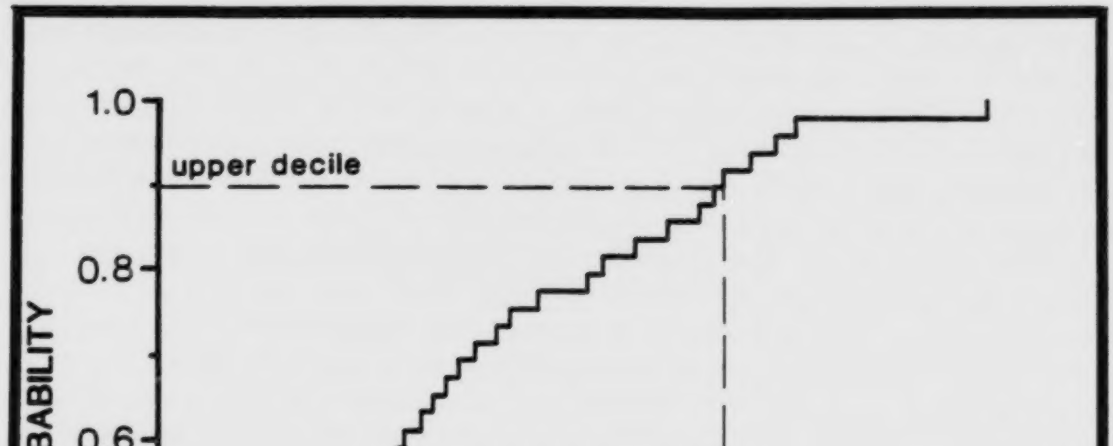

Figure 5. Cumulative Probability Distribution and Key Statistics of a Return Parameter for Economic Deposits

covery risk for a mining company is that there is a large difference between the average exploration cost required to find and delineate an economic deposit and the exploration funds required to ensure success. For example, the exploration funds required to be 90 percent sure of finding at least one economic discovery are more than 2-times greater than the average exploration cost associated with an economic discovery.

Summing Up

Appraisals of the potential value of the mineral supply process are derived from estimates of the exploration expenditures, development costs, and operating revenues and costs associated with an economic deposit. The evaluation procedure adopted mixes historical discoveries and developments with future prices to arrive at a "present day" appraisal of these discoveries. In seeking explanations for overall results, the two main components of expected value - exploration expenditures, and the returns associated with the discovery of economic deposits - should be subjected to more detailed examination. Cumulative probability distributions are used to portray the profile of possible returns.

The methodology suggested here provides an objective basis for assessing the economic potential of base metal and gold supply in Newfoundland and measuring the direct effects of government policies.

3. BASE METAL AND GOLD SUPPLY IN NEWFOUNDLAND, THE APPALACHIAN REGION AND CANADA: THE DATA BASE

Study Specifications

The assessments of base metal and gold mining potential provided in this study are based on the 40-year period 1946-85. This time period is subdivided into four decades - 1946-55, 1956-65, 1966-75, and 1976-85 - to examine time trends in exploration and development characteristics.

Money values unless otherwise specified are expressed in constant 1987 Canadian dollars. Discount rates and costs of capital are therefore expressed as real rather than nominal rates. Inflation is taken into account to correctly assess tax allowances and payments.

Trends in historical current-dollar statistics that are purely inflationary are removed by applying the Gross Domestic Product (GDP) Implicit Price Index. This aggregate price index provides a good approximation of the economy-wide rate of inflation. The GDP Implicit Price Index and the inflation multiplier series derived from it to convert historical data to 1987-dollar equivalents are shown in appendix I.

One aspect of our evaluation is to determine which of the mineral deposits discovered in the past would be economic under today's conditions. An economic deposit is defined as a discovery that realizes a total revenue of at least $20 million and a rate of return of at least 8 percent. The $20 million minimum size ensures that any deposit of significance is included in the evaluation. The 8-percent rate-of-return investment margin has been selected as a best estimate of the weighted average cost of capital for mineral investment funds. The effects of profitability thresholds of 5 percent and 12 percent on exploration and development potential are also examined.

Total Exploration Expenditures

Estimates of total exploration expenditures are required for each commodity grouping, geographic region, and time interval of interest. The intention is to include all costs associated with searching for and delineating the possible economic discoveries of interest. Unsuccessful exploration expenditures are of course the main component of these costs. Total exploration expenditures are difficult to estimate, mainly because government statistics are too aggregated to be directly applicable.

The approach used to estimate mineral exploration expenditures for study purposes is described in appendix II. A large number of sources are utilized in deriving the final study series. Statistics and subjective judgments have been obtained from federal and provincial government departments as well as from exploration personnel in mining companies.

As in earlier CRS studies, Dominion Bureau of Statistics' series on the cost of prospecting have been used extensively for the 1946-63 period.[5] For the remainder of the study period, Statistics Canada data for both on-property and off-property exploration expenditures are the primary source. Only off-property expenditures were used in earlier CRS studies. There are several reasons for including on-property expenditures now:

- a substantial amount of primary exploration for new deposits is carried out on existing mining leases;
- our evaluation of development potential is based on the most complete ore reserve estimates available;
- on-property exploration is a valid activity to be included in total exploration for evaluation purposes.

More data from provincial government sources have been used in the present study than in the past. Statistics Canada expenditures have been augmented in some years to reflect more comprehensive provincial totals.

Base metal exploration expenditures are derived as a residual by deducting expenditures for all other metals from a total metallic mineral exploration series. Series for other metals - including nickel, uranium, and iron ore - are based on more reliable data, and have been constructed in greater detail than in earlier studies. As a result, the base metal series derived in appendix II should also be more dependable and complete. Gold exploration expenditure estimates are similar to the series assembled for a recent CRS project.[6] The present series, however, includes better figures for 1985. Some adjustments have also been made to the totals for earlier years based on new information and refinements in our estimating procedure.

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[5]. For a description of the method of estimation and sources of data used for base metal exploration expenditures in earlier CRS studies, see appendix II, Effects of Taxation on Base Metal Mining in Canada, B.W. Mackenzie and M.L. Bilodeau, Centre for Resource Studies, Queen's University, 1979.

The resulting series of exploration expenditures are presented in appendix II. Table 1 summarizes these expenditures by commodity grouping and time interval for Newfoundland, the appalachian region, and Canada. Exploration expenditures in Newfoundland total $321 million for the 1946-85 period, split between base metals (90 percent) and gold (10 percent). Newfoundland is shown to account for 36 percent of exploration activity in the appalachian region and 4 percent of Canada-wide expenditures during the study period.

Annual Exploration Budget Rate

An assumption is required concerning the annual exploration budget of a mining company as part of the determination of the average exploration time that would be needed to discover an economic deposit.

On the basis of discussions with exploration personnel and observations of both successful and unsuccessful exploration at work, a $6.0-million annual exploration budget has been chosen as an efficient level for an exploration organization. While opinions on this subject vary and the $6.0 million figure may be debated, there can be little doubt that the most efficient budget rate lies within the range of $3.0 to $9.0 million per year.

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[6] . See "Long-Term Breakeven Price for Canadian Gold Supply", D. Cranstone, B. Mackenzie, and M. Doggett, in Long-Term Prospects for Gold Mining, edited by B. Mackenzie and R. Gesing, Centre for Resource Studies, Queen's University, 1987.

Table 1

TOTAL BASE METAL AND GOLD EXPLORATION EXPENDITURES
(millions of constant 1987 Canadian dollars)

Commodity Grouping and Time Interval	Newfoundland	Appalachian Region	Canada
Base Metals:			
1946-55	37	93	226
1956-65	77	190	1,061
1966-75	109	263	2,165
1976-85	66	230	1,812
1946-85	289	776	5,264
Gold:			
1946-55	2	8	190
1956-65	4	15	172
1966-75	1	11	295
1976-85	25	83	1,740
1946-85	32	117	2,397
Base Metals and Gold:			
1946-55	39	101	416
1956-65	81	205	1,233
1966-75	110	274	2,460
1976-85	91	313	3,552
1946-85	321	893	7,661

The $6.0-million budget is considered large enough to afford the best possible exploration skills and techniques, and small enough to encourage a high degree of motivation and organizational efficiency. Assessments are also carried out for annual exploration budgets of $3.0 million and $9.0 million. Total exploration expenditures are not changed by these budget rate variants. All that is affected is the estimated average time required for an exploration organization to discover an economic deposit.

Possible Economic Discoveries for Evaluation

In Newfoundland, 29 base metal and gold discoveries that could possibly satisfy our "economic deposit" definition are selected for evaluation. The Newfoundland discoveries are part of 68 possible economic deposits in the appalachian region and 539 discoveries in the Canada-wide data base. These deposits are listed in alphabetical order in appendix III, classified by commodity grouping, geographic region, and discovery date.

A discovery is considered to have been made when the deposit that ultimately forms the basis for mine development was first encountered, usually by drilling. Deposits are treated individually if their discovery required essentially independent primary exploration programs. The intention is to include all known deposits of at least 200,000 tonnes that offer medium-term potential for development. A few exceptions are made below this size threshold for deposits of exceptionally high grade. A listing of other deposits considered but not included in our evaluation is given in appendix IV with reasons for their exclusion.

The distribution of possible economic discoveries in Newfoundland, the appalachian region, and Canada is summarized in table 2. The 18 significant deposits discovered in Newfoundland during the 1946-85 period are, like the associated exploration expenditures, heavily weighted by base metals (16 deposits) with only two gold discoveries.[7] Newfoundland is shown to account for 37 percent of the deposits found during the study period in the appalachian region and for 4 percent of the discoveries made in Canada.

---

[7]. The Duck Pond deposit, discovered in 1986, is included in our study assessments because the exploration activity leading up to this important find is mostly covered by our expenditure totals.

Table 2

NUMBER OF POSSIBLE ECONOMIC DEPOSITS FOR EVALUATION

Commodity Grouping and Discovery Date	Newfoundland	Appalachian Region	Canada
Base Metals:			
Pre-1946	11	19	102
1946-55	3	12	61
1956-65	5	15	92
1966-75	4	10	103
1976-85	4	5	47
1946-85			
Total	27	61	405
Gold:			
1946-55	-	-	15
1956-65	-	-	21
1966-75	-	1	13
1976-85	2	6	85
1946-85	2	7	134
Base Metals and Gold:			
1946-55	3	12	76
1956-65	5	15	113
1966-75	4	11	116
1976-85	6	11	132
1946-85	18	49	437

Note: the pre-1946 base metal discoveries are included in the base metals "total".

While the base metal deposits discovered prior to 1946 - 11 in Newfoundland, 19 in the appalachian region, 102 in Canada - cannot be included in the overall analysis of mineral supply potential, they help provide a more complete picture of mineral endowment characteristics, the time trend of returns from economic discoveries, and mine development potential.[8]

General Market Estimates

General market estimates are made to evaluate the time distribution of revenues for each of the possible economic discoveries. Since metal price is both the most important and the most uncertain variable in the assessment of cash flows, cash flows are evaluated as a function of price. An expected or mean price outlook is bounded by upper- and lower-limit prices for each mineral commodity. The prices used are shown in table 3. These are long-term average price estimates, the period of which is intended to correspond to the time frame of the three-phase mineral supply process being evaluated.

The assessment of costs and revenues assumes that concentrate or bullion is produced at each possible mine. General net smelter return conditions for copper, lead, and zinc concentrates are used to convert the forecast metal prices to a revenue estimate for the sale of concentrate at the smelter. Concentrate transportation costs are then deducted to work the smelter payment back to a minesite value. In the case of gold deposits, all-inclusive marketing charges are levied for impure bullion and gold concentrate products. The smelter return conditions, concentrate transportation costs, and gold marketing charges used in the study are given in appendix V.

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[8]. To augment the relatively small sample size of base metal and gold experience in Newfoundland, an attempt was made to enlarge the study coverage in two other ways. First, uranium and rare metal activities were included. This increased total exploration expenditures by $57 million, and added four uranium deposits and the Strange Lake rare metals deposit to the list of possible economic discoveries. Second, the study period was extended to include 1986, adding $12 million of exploration expenditures and three possible economic gold deposits. Since the estimates used for this purpose were speculative and the outcome did not turn out to be very significant, results for this enlarged Newfoundland variant are not included in the final report. The data are available, however, for possible future use.

Table 3

LONG-TERM PRICE VARIANTS FOR MINERAL COMMODITIES
(1987 United States dollars)

Metal	Price Basis	Price Variants Lower-Limit	Expected	Upper-Limit
Cadmium	pound	2.00	3.00	4.00
Copper	pound	0.80	1.00	1.25
Gold	ounce	250	400	500
Iron[9]	mtu in concentrate	0.18	0.22	0.25
Lead	pound	0.30	0.35	0.45
Molybdenum	pound in concentrate	2.50	3.50	5.00
Silver	ounce	4.00	6.00	9.00
Zinc	pound	0.35	0.45	0.50
Exchange Rate	US$/C$	0.80	0.65	0.55

mtu: metric tonne unit

According to the methodology adopted, the metal price variants specified here affect ore reserves in two ways. First, prices are a determinant of the number of deposits which would be economically viable to develop. Second, for each of the possible economic discoveries evaluated, ore reserve categories are specified wherever appropriate. These categories are considered for mining in the order specified. For a category to be accepted for mining, projected revenues must at least equal operating costs. Thus, the number of categories which would be mined for each economic deposit is also a function of metal price levels. These features of our evaluation procedure represent a crude form of cut-off grade determination appropriate for the broad type of economic assessment being made.

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[9]. These iron ore concentrate prices are used to evaluate the Tasu copper-iron ore deposit in British Columbia, considered as a base metal deposit for study purposes.

Estimates for Individual Deposits

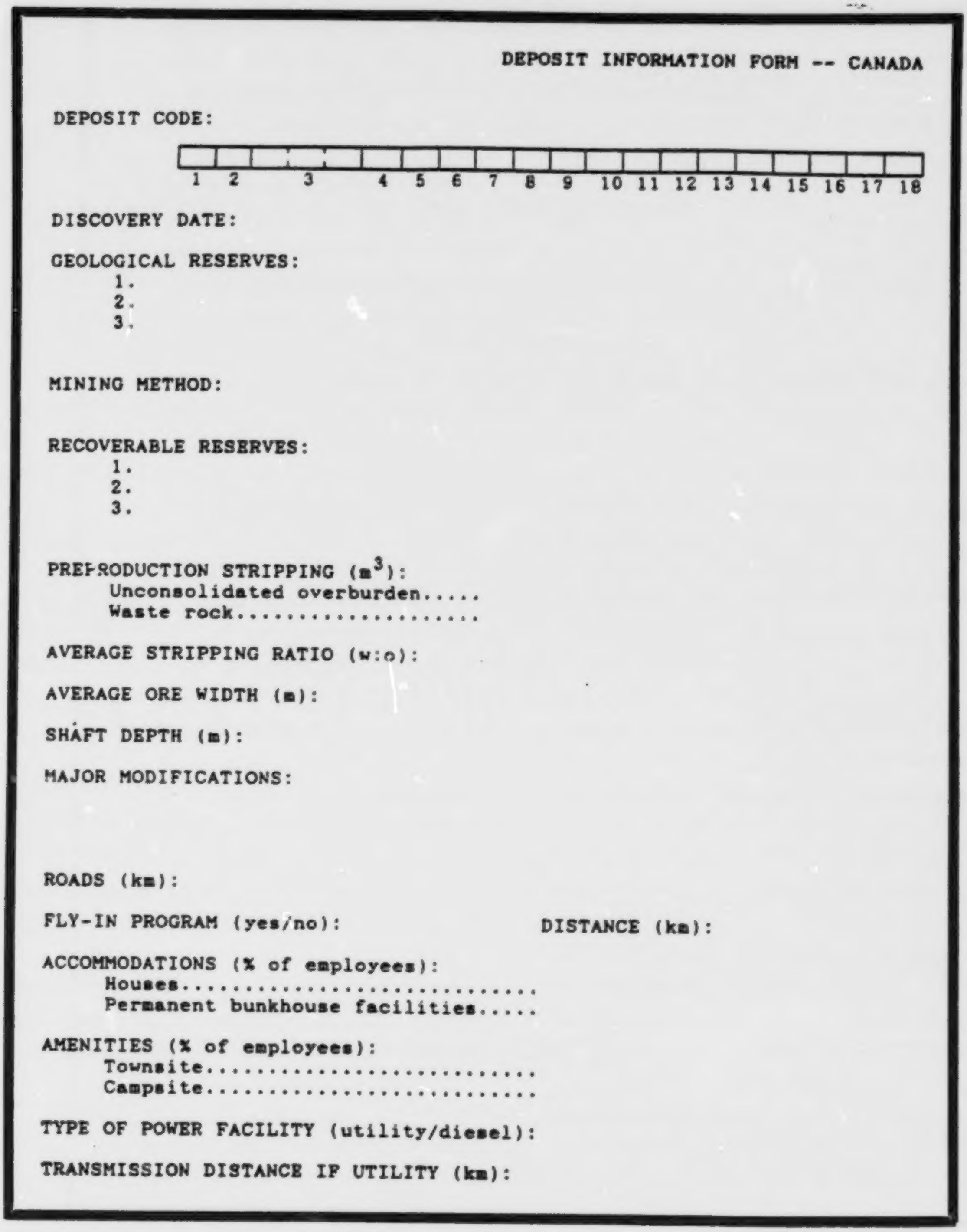
Deposit-specific estimates of recoverable ore reserves, mine and mill capacities, preproduction period, preproduction capital cost including the working capital requirement, the cost of major modifications, sustaining capital, operating cost, mill recovery factors, concentrate grades, and concentrate transportation, are calculated for each of the 539 possible economic discoveries, based on present-day economic and technological conditions. These deposit estimates utilize actual historical data and feasibility study estimates to the extent available. Otherwise, generalized costing relationships are applied, reflecting an order-of-magnitude level of accuracy.[10]

The form in which the basic estimates are provided for each deposit is shown in figure 6. The coding scheme maintains the anonymity of the deposits and facilitates their classification for analysis. Coding specifies the following characteristics of the deposit.

1	exploration environment
2	province or territory
3	deposit code
4,5,6	geological classifications
7	mining method

---

[10] A new set of deposit costing relationships has been developed for study purposes with the assistance of T.A. O'Hara. Evaluation procedures based on these relationships are outlined here and in appendix V. It has not however been possible to fully implement the new system in this study. The results presented in chapter 4-7 are therefore in part based on indexing deposit costing relationships developed in the early 1980s.



DEPOSIT INFORMATION FORM -- CANADA

DEPOSIT CODE:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18

DISCOVERY DATE:

GEOLOGICAL RESERVES:
1.
2.
3.

MINING METHOD:

RECOVERABLE RESERVES:
1.
2.
3.

PREPRODUCTION STRIPPING (m^3):
Unconsolidated overburden.....
Waste rock..................

AVERAGE STRIPPING RATIO (w:o):

AVERAGE ORE WIDTH (m):

SHAFT DEPTH (m):

MAJOR MODIFICATIONS:

ROADS (km):

FLY-IN PROGRAM (yes/no): DISTANCE (km):

ACCOMMODATIONS (% of employees):
Houses...........................
Permanent bunkhouse facilities.....

AMENITIES (% of employees):
Townsite.........................
Campsite.........................

TYPE OF POWER FACILITY (utility/diesel):

TRANSMISSION DISTANCE IF UTILITY (km):

Figure 6. Deposit Estimate Form

REGIONAL MILL ALTERNATIVE:
Capacity (tonnes per year).........
Ore transport distance (km)........
Roads required (km)................

CONCENTRATE TRANSPORTATION:

Commodity ________ ________ ________ ________
Destination
Road distance (km)
Rail distance (km)
Ocean route

ACTUAL INFORMATION

ORE CAPACITY (tonnes per year):

MINE RECOVERY (%):

MINE DILUTION (%):

AVERAGE ORE WIDTH (m):

PREPRODUCTION PERIOD (years):

PREPRODUCTION CAPITAL COSTS ($ million or % change):

Mine development
Mine plant and equipment
Mill facilities
Infrastructure
Working capital
Total

Infrastructure Breakdown
Roads
Housing
Townsite
Power
Total

OPERATING COSTS ($ per tonne of ore or % change):

Mining
Milling
Overheads
Total

METALLURGICAL RECOVERIES (%):

CONCENTRATE GRADES (%):

REGIONAL MILL ALTERNATIVE:
Capital cost ($ million)................
Operating cost ($ per tonne of ore).....

Figure 6. Deposit Estimate Form (continued)

8	underground stoping method
9	general surface services
10	mine and mill site preparation
11	host rock conditions for shaft sinking
12	ground conditions for pouring concrete foundations
13	temperature conditions
14	grinding conditions
15,16	ore type for mineral processing
17	conditions for tailings storage
18	investment tax credit

The first sheet of deposit estimates (figure 6) and the top of the second sheet (to the dotted line) itemize the information which must be specified to evaluate a deposit on the basis of the order-of-magnitude costing relationships. Estimates based on actual deposit data and feasibility study projections are entered below the dotted line on the second sheet.

The general deposit costing relationships used in the appraisal when actual data or specific estimates are not available, provide an order-of-magnitude (±30 percent) level of accuracy. These relationships are outlined in appendix V.

With respect to processing facilities, where more than one deposit of the same type exists in a region, deposits are evaluated assuming utilization of a common mill facility. The overall regional mill capacity is specified, as is the distance between the deposit and the mill. The deposit is allocated a proportion of the mill capital cost based on relative capacities. The distance is used to estimate a road-haulage transportation cost for the ore. Additional road construction may be specified.

Table 4 presents average mine development parameters for all deposits in the study data base. These statistics may be viewed as providing representative deposit profiles. The following points of interest arise from these results:

- the small average size of Newfoundland base metal deposits suggests that a multi-billion dollar Newfoundland version of Brunswick 12 or Kidd Creek has not yet been discovered;

Table 4

AVERAGE MINE DEVELOPMENT PARAMETERS FOR BASE METAL AND GOLD DEPOSITS

Commodity Grouping and Region	Possible Economic Discoveries (number)	Recoverable Ore Reserves (t mill.)	Annual Mill Capacity (t thou.)	Productive Mine Life (years)	Preproduction Capital Cost ($ mill.)	Unit Production Costs ($/t)	Unit Revenue ($/t)	Total Revenue ($ mill.)
Base Metals:								
Newfoundland	27	3	215	9	37	67	96	229
Appalachian Region	61	11	537	11	50	64	74	534
Canada	405	25	1,120	11	74	77	77	635
Gold:								
Newfoundland	2	9	495	16	57	56	113	676
Appalachian Region	7	3	280	11	21	50	118	287
Canada	134	3	245	9	34	67	149	332
Base Metals and Gold:								
Newfoundland	29	3	234	10	38	67	97	260
Appalachian Region	68	10	511	11	47	62	79	509
Canada	539	19	902	11	64	75	95	560

Note: the unit and total revenue estimates are based on expected metal prices and evaluated at the minesite.

- the relatively large size of the Hope Brook deposit is apparent from the recoverable ore reserve and total revenue averages for gold deposits;

- in terms of recoverable ore reserves, base metal deposits are shown to be much larger on average than gold deposits except in Newfoundland where the Hope Brook discovery is so influential;

- revenue per tonne provides a measure of recoverable, payable ore grade. Based on this indicator and the expected metal prices assumed in table 4, the average grade of gold deposits for Canada overall is found to be about twice as high as the average grade of base metal deposits;

- the total revenue potential of base metal deposits is shown to be significantly greater on average than for gold deposits (with the exception again of Newfoundland). In this respect, the larger recoverable ore reserves for base metal deposits more than offset their relatively low payable ore grade (unit revenue);

- productive mine lives typically average between 9 and 11 years;

- direct relationships are shown to exist between several of the mine development parameters. Annual mill capacity is obviously a function of the size of ore reserves. Preproduction capital cost is determined in part by the required capacity. Unit production costs are partially a function of the scale of operation (capacity), depending as well on the mining method (particularly on whether the deposit is mined as an open pit or underground operation).

Critique of the Data Base

The information utilized for this study has been assembled on a continuing basis since 1972. Nevertheless, there are a number of data base limitations.

First, possible economic deposits are classified on the basis of their discovery dates. As there is an uncertain time lag between the start of exploration and the discovery of a deposit, it is possible that exploration expenditures included in the economic assessment for one time interval, may result in discoveries included in the following time interval, or vice versa. Since we are examining four 10-year intervals, this discrepancy should not significantly alter time trends. It may be important however if, as a result, possible economic deposits are excluded from the overall time period. For this reason, three discoveries made early in 1986 (including Duck Pond in Newfoundland) have been included in the evaluation. The 40-year period chosen is considered to be of sufficient duration to minimize these spillover effects.

Second, the data base for older mines tends to be more complete than that for the more recent discoveries. This is especially important with respect to ore reserve estimates, since development and production typically proceed on the basis of partial delineation results. Our objective has been to include as complete an estimate as possible for the tonnage and grade characteristics of each deposit. There is nevertheless an inevitable tendency to undervalue the appraisals, especially for deposits discovered in the most recent time interval. The possible undervaluation is particularly significant with respect to ore reserve tonnage. This problem can only be eased by periodic updating and improvement of the data base.

It can be argued that the use of historical exploration expenditures results in overestimating the exploration costs that would be required under today's conditions. This contention is based on the increasing effectiveness of exploration. Thus, it would presently require lower exploration expenditures to find the deposits which were discovered historically. However, as discussed in chapter 2, both depletion effects and advances in technology act over time, leading to either an increase or a decrease in finding costs, depending on their resultant. In this study, these effects are examined by studying time trends within the overall 40-year study period. Otherwise, it is reasoned that the cost of making a future discovery will be similar to the cost in the past.

These and other shortcomings in the data base reflect a compromise between the availability of data and the research limitations imposed by time constraints. While there is certainly room for improvement, it is suggested that the existing data base is sufficient to support a useful and meaningful appraisal of base metal and gold supply potential in Newfoundland.

Data Processing

The data base is processed by computer programs developed for the Centre for Resource Studies by Professor Michel Bilodeau, Department of Mining and Metallurgical Engineering, McGill University. There are three separate procedures which are named MINDEC 1, MINDEC 2 and MINDEC 3.

MINDEC 1 is a program that computes the development and production characteristics of each possible deposit. The MINDEC 2 program then retrieves the cash flow elements and economic characteristics of the economic mineral deposits, computes their averages, lists the unit development and production components of cash flow for an economic deposit, and plots cumulative probability distributions. MINDEC 3 is a program to retrieve the yearly cash flow elements of economic mineral deposits. It then computes the time distribution of average cash flows for an economic deposit and associated economic characteristics with and without the average exploration period cash flows.

Variants for Analysis

To summarize, our evaluation of base metal and gold mining potential includes the following variants.

- potential value of mineral supply in Newfoundland
    - base metals and gold together
    - base metals and gold compared
    - return characteristics of economic deposits
- sensitivity of mineral supply potential to key study parameters
    - metal price variants
    - annual exploration budget variants
    - cost of capital variants
- Newfoundland's competitive position in the appalachian region and in Canada
    - base metals and gold together
    - base metal potential
    - gold potential
    - time trends
    - return characteristics of economic deposits

4. POTENTIAL VALUE OF BASE METAL AND GOLD MINING IN NEWFOUNDLAND

Base Case Results

The base case conditions which are used as a standard of comparison with other results, are:

- 18 possible economic base metal and gold deposits discovered in Newfoundland during the 1946-85 period;
- expected metal price conditions;
- 8-percent cost of capital and minimum acceptable rate of return for an economic deposit;
- $6-million annual exploration budget.

Under these conditions, 10 of the 18 deposits evaluated are found to be economic. The cost and revenue characteristics of the 10 economic deposits are used to assess the time distribution of average cash flows for an economic deposit. The undiscounted cash flow values are summarized in table 5 and presented in figure 7. The average cash flow generated by an economic deposit is $175 million.

Based on the cash flow results portrayed in figure 7, assessments of expected value criteria are presented in table 6. As shown, base metal and gold supply experience in Newfoundland represents an exploration expenditure of $321 million, the result of which has been the discovery of 10 economic deposits. The average cost required to find and delineate an economic deposit is therefore about $32 million, equivalent to $25 million (E) when discounted at 8 percent to the start of the exploration phase. The reward for this exploration expenditure is an average return of $47 million (R) for each economic discovery. This return, the resultant of average development and production phase cash flows, is also expressed as a present value at the start of exploration. Consequently, the expected value of mineral supply per economic deposit is $47 million minus $25 million, or $22 million (EV). This means that, on average, based on the assumed conditions, $22 million of new wealth or economic surplus is associated with the discovery of an economic deposit. Alternatively, the expected value of mineral supply may be expressed as a 12-percent expected rate of return in relation to the 8-percent cost of capital.

Table 5

AVERAGE CASH FLOW CHARACTERISTICS FOR AN ECONOMIC DEPOSIT UNDER BASE CASE CONDITIONS

Characteristic	Newfoundland
Time periods (years):	
Exploration phase	5
Development phase (maximum)	4
Production phase (maximum)	20
Undiscounted values ($ million):	
Revenue	467
Exploration expenditure	32
Development capital cost	47
Production cost	213
Cash flow	175

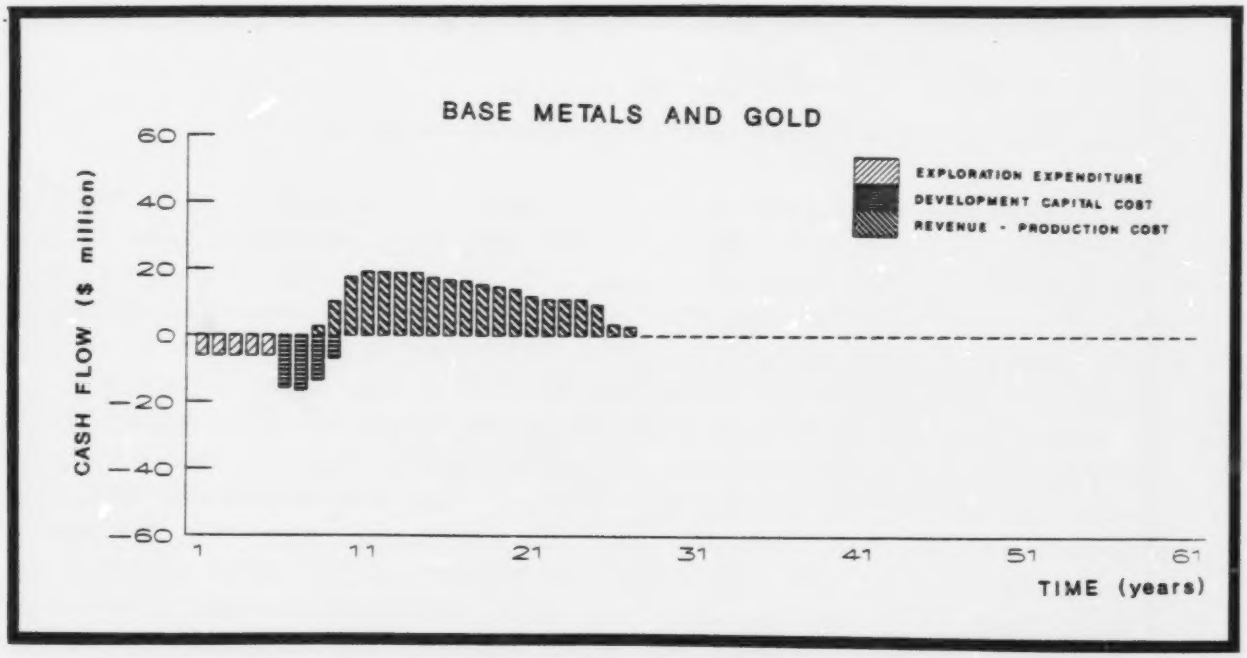


Figure 7. Time Distribution of Average Cash Flows for an Economic Deposit: Base Case Conditions

Table 6

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND UNDER BASE CASE CONDITIONS

Characteristic	Newfoundland
Total exploration expenditures ($ million)	321
Number of economic discoveries	10
Average exploration expenditure (E,$ million)	25
Average return (R,$ million)	47
Expected value (EV,$ million)	22
Rate of return (percent)	12

Base case results indicate that base metal and gold mining have the potential to increase significantly the wealth available to Newfoundland society. Having considered all direct costs associated with the mineral supply process, we estimate that $22 million would be available on average for sharing between industry and government for each economic deposit discovered.

Comparison of Base Metal and Gold Supply Potential

Separating the base case into two commodity groups - base metals and gold - we find that half of the possible economic base metal discoveries (8) and both of the gold discoveries are economic. The time distributions of average cash flows for an economic deposit are compared in figure 8 and table 7. Assessments of the expected values of base metal and gold supply are summarized in table 8.

Results indicate that the potential value of both base metal and gold supply are positive. The expected values per economic discovery are shown to be $15 million and $58 million, and the expected rates of return are 11 percent and 17 percent, respectively. While the economic potential of gold supply is higher than for base metals, the gold exploration and discovery experience is too limited for this comparative finding to be of long-term significance.

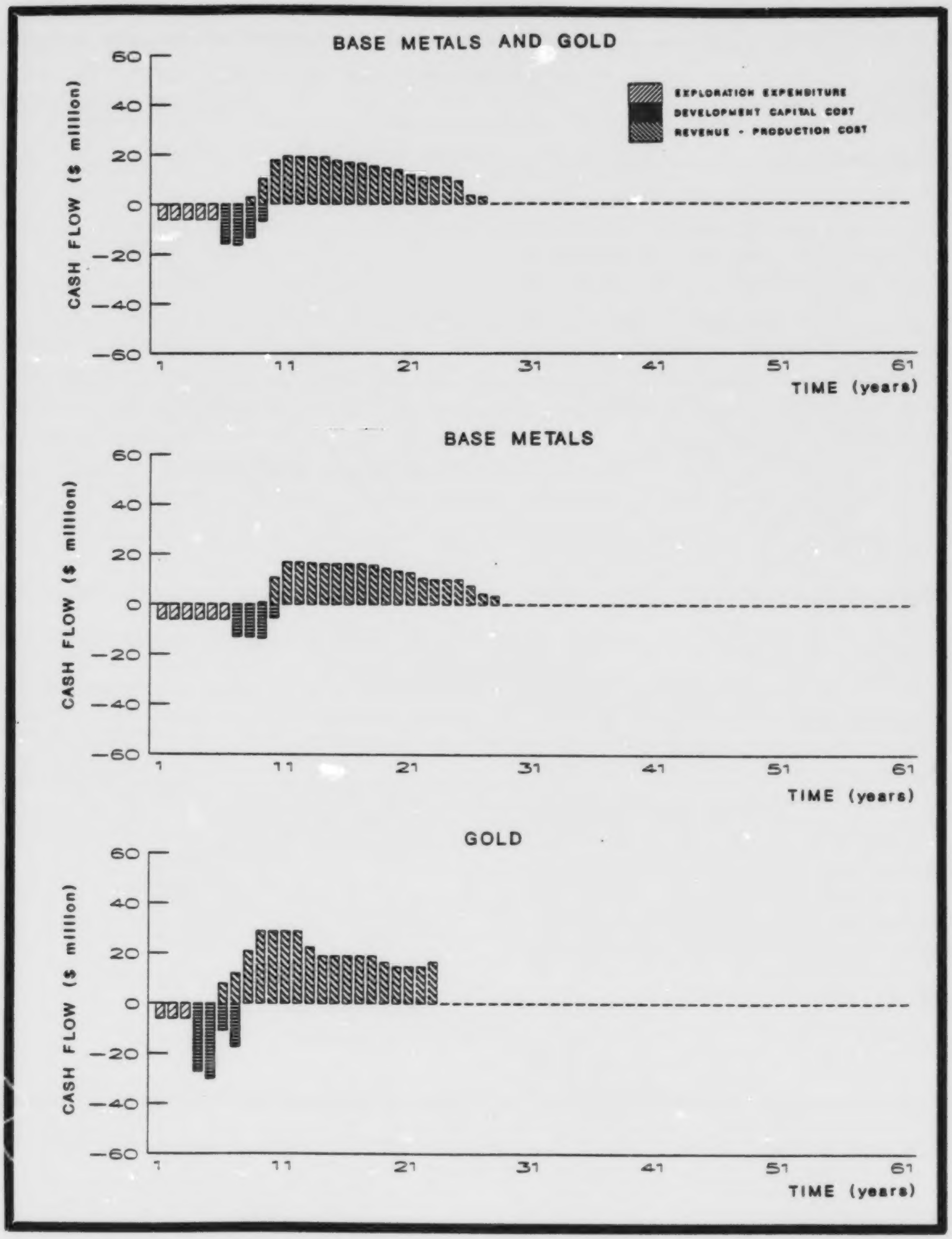


Figure 8. Time Distributions of Average Cash Flows for an Economic Deposit: Comparison of Base Metal and Gold Exploration

Table 7

AVERAGE CASH FLOW CHARACTERISTICS FOR AN ECONOMIC DEPOSIT BY COMMODITY GROUPING

Characteristic	Base Metals	Gold
Time periods (years):		
Exploration phase	6	3
Development phase (maximum)	4	2
Production phase (maximum)	20	18
Undiscounted values ($ million):		
Revenue	415	676
Exploration expenditure	36	16
Development capital cost	45	57
Production cost	178	353
Cash flow	156	250

Table 8

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND BY COMMODITY GROUPING

Characteristic	Base Metals	Gold
Total exploration expenditures ($ million)	289	32
Number of economic discoveries	8	2
Average exploration expenditure (E,$ million)	28	14
Average return (R,$ million)	43	72
Expected value (EV,$ million)	15	58
Rate of return (percent)	11	17

Return Characteristics of Economic Deposits

Base Case Results

The return characteristics of economic deposits are determined by the time distribution of average cash flows as viewed from the start of development. This distribution is illustrated in figure 9 for base case conditions. This diagram reproduces the development and production phase cash flows shown in figure 7.

The average return realized from an economic deposit can be characterized by the expected net present value of $71 million and the expected rate of return of 25 percent assessed from the cash flow distribution. Given an economic mineral deposit at the start of development, mining is shown to offer excellent potential for profitable investment and wealth creation.

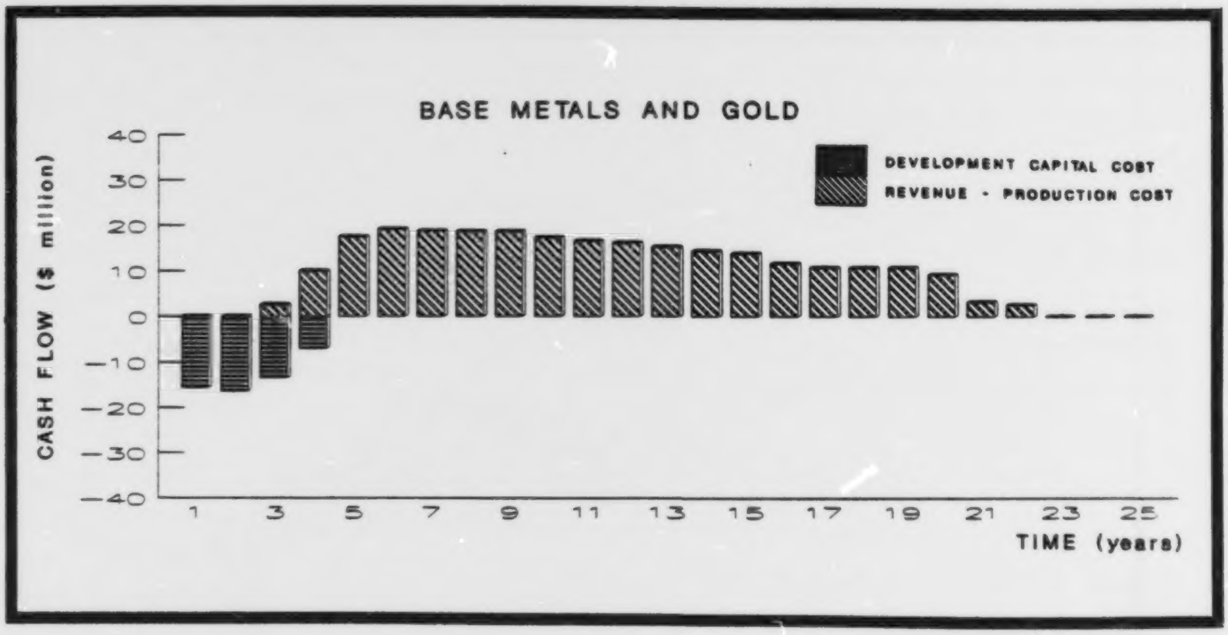


Figure 9. Time Distribution of Average Cash Flows for an Economic Deposit as Viewed from the Start of Development: Base Case Conditions

The differences between these return characteristics at the start of development - $71 million and 25 percent - and the long-term expected values previously evaluated at the start of exploration - $22 million and 12 percent - provide an economic measure of exploration's contribution to the mineral supply process. Successful exploration is required to realize the enhanced economic returns offered at the start of development. This enhancement of expected values is the result of a selective, sequential information-gathering process that, starting with a broad environment of interest (Newfoundland in this case), resolves the discovery and geologic risks, finding and delineating a mineral deposit which has economic potential for development.

Comparison of Returns for Base Metal and Gold Mine Development Potential

The time distribution of average cash flows for economic base metal and gold deposits as viewed from the start of development are compared in figure 10. These distributions are the same as those previously shown for the development and production phases in figure 8. The associated economic criteria are summarized in table 9.

Table 9

EXPECTED VALUES FOR MINE DEVELOPMENT IN NEWFOUNDLAND BY COMMODITY GROUPING

Characteristic	Base Metals and Gold	Base Metals	Gold
Total revenue ($ million)	467	415	676
Net Present Value ($ million)	71	67	88
Rate of return (percent)	25	27	22

Note: the net present value is determined by discounting the cash flows at 8 percent to the start of development.

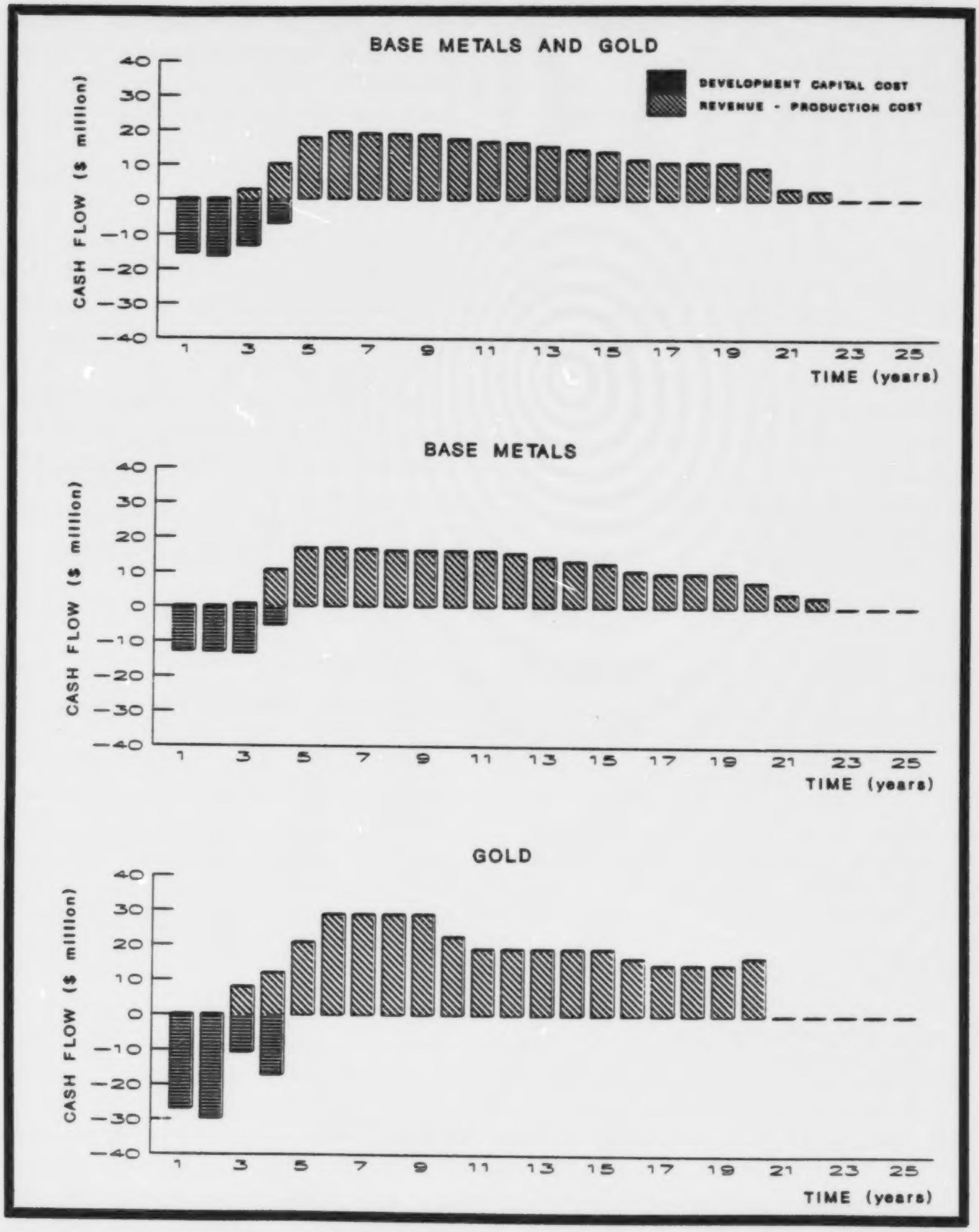


Figure 10. Time Distributions of Average Cash Flows for an Economic Deposit as Viewed from the Start of Development: Comparison of Returns for Base Metal and Gold Deposits

Base metal and gold deposits are shown to have quite similar return characteristics on average. The expected values for gold mine development are however based on a sample size of only two economic deposits.

Variability of Returns for Individual Deposits

The cash flow distribution presented in figure 9 averages together the return characteristics of 10 economic discoveries. In addition, 3 base metal deposits found in Newfoundland prior to 1946 are assessed as economic for the assumed base case conditions. These 13 economic discoveries are listed in table 10. The viability of mine development is determined in each case by the deposit's particular characteristics. These are averaged together with other widely-ranging sets of deposit characteristics to appraise the composite profile shown in figure 9 for the 10 economic discoveries evaluated for the 1946-85 period.

Table 10

ECONOMIC DEPOSITS ASSESSED IN NEWFOUNDLAND FOR BASE CASE CONDITIONS

Cape Ray
Daniel's Harbour
Duck Pond
Hope Brook
Lucky Strike*
MacLean
MacLean Extension
Ming
Old Buchans*
Oriental No. 1*
Oriental No. 2
Point Leamington
Rothermere

* pre-1946 discovery

The high degree of variability in the returns associated with the development of economic discoveries - a consequence of the variability in tonnage, grade, and other geologic characteristics among economic deposits - is an essential feature of the mineral supply process. To illustrate this point, we have examined the cumulative frequency distributions of total revenue, net present value, and rate of return for the 13 economic deposits assessed in Newfoundland. Key statistics from these distributions are summarized in table 11.

Table 11

VARIABILITY OF THE RETURN FOR ECONOMIC DEPOSITS IN NEWFOUNDLAND

Statistic	Total Revenue ($ million)	Net Present Value ($ million)	Rate of Return (percent)
Upper decile	1,184	281	65
Upper quartile	836	140	40
Mean (average)	465	91	32
Median	377	52	25
Lower quartile	181	24	18
Lower decile	43	3	14

Notes: based on expected metal prices; total revenue is evaluated at the minesite; net present value is determined at the start of development using an 8-percent discount rate; includes economic base metal deposits discovered before 1946.

Total revenue, evaluated in this case at the minesite, reflects deposit size. Table 11 indicates a 28-times difference in size between the lower-decile and upper-decile economic deposits around the mean value of $465 million. Rate of return measures the profitability of an economic deposit. There is a 5-fold difference in rate of return between the lower-decile and upper-decile economic deposits (14 percent and 65 percent respectively). Turning to the net present value results, which provide a combined indicator of size and profitability characteristics, the mean or average potential value is $91 million. The variability of the return, given an economic deposit, is illustrated by the almost 100-fold difference in value between the lower-decile and upper-decile economic deposits ($3 million and $281 million respectively).

All three distributions are shown to be somewhat skewed, the mean value statistics falling between the median and the upper-quartile deposit values. This skewness occurs because, as shown in figure 11, there tends to be a relatively large proportion of low-value economic discoveries and two or three of very high value.

With respect to government policy formulation, the main message that the results presented in table 11 convey is that there is no such thing as a "typical deposit". Thus, flexibility is required in government policies to equitably and efficiently accommodate the wide range of returns associated with mine development.

Summing Up

The economic potential for gold and base metal exploration and mine development in Newfoundland is shown to be substantial.

In the long-term, as viewed from the start of exploration, Newfoundland's mineral supply process is characterized by an expected value of $22 million per economic deposit discovered and by a 12-percent expected rate of return in relation to a projected 8-percent cost of capital.

In the medium-term, the economic return characteristics at the start of mine development are typified by a net present value of $71 million per economic deposit and by a 25-percent rate of return on investment. The enhancement in potential values which occurs between the start of exploration and the start of mine development illustrates exploration's economic contribution to the mineral supply process.

A high degree of variability is shown in the return characteristics of individual economic deposits around the composite values appraised. For example, an almost 100-fold difference in net present value is shown between the lower-decile and upper-decile economic deposits ($3 million and $281 million respectively). These striking differences reflect the underlying variability in deposit size, grade, and other geological parameters among the economic discoveries.

More specific results for both base metal and gold commodity groupings are shown to be decidedly positive. While the economic potential of gold supply is higher than for base metals, the gold exploration and discovery experience in Newfoundland is as yet too limited for this comparative finding to be of long-term significance.

The representative features of mineral exploration and mine development in Newfoundland assessed here are broad generalizations across a wide range of experience. Any particular situation should not, of course, be expected to reproduce these averages. Nevertheless, the numerical values appraised provide a useful overall portrait of the mineral supply process that can be used when looking ahead to assess the general requirements for and consequences of mineral policy formulation and decision making.

5. SENSITIVITY OF POTENTIAL VALUES TO KEY STUDY PARAMETERS

The potential value assessments presented in chapter 4 are based on a particular set of base case conditions. We are uncertain about a number of the conditions assumed. In the present chapter, the more general validity of the results is examined using sensitivity analysis. The key parameters selected for attention here are metal prices, the annual exploration budget, and the cost of capital.

Metal Price Variants

The expected metal prices used in chapter 4 represent highly uncertain "best" estimates. Potential value assessments for mineral exploration as a function of the lower-limit, expected, and upper-limit metal price conditions specified in table 3 are shown in table 12 and figure 11.

Table 12

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND AS A FUNCTION OF METAL PRICE

	Price Variant		
Characteristic	Lower-Limit	Expected	Upper-Limit
Total exploration expenditures ($ mill.)	321	321	321
Number of economic discoveries	0	10	11
Average exploration expenditure (E,$ mill.)	-	25	23
Average return (R,$ mill.)	-	47	120
Expected value (EV,$ mill.)	-	22	97
Rate of Return (percent)	-	12	22

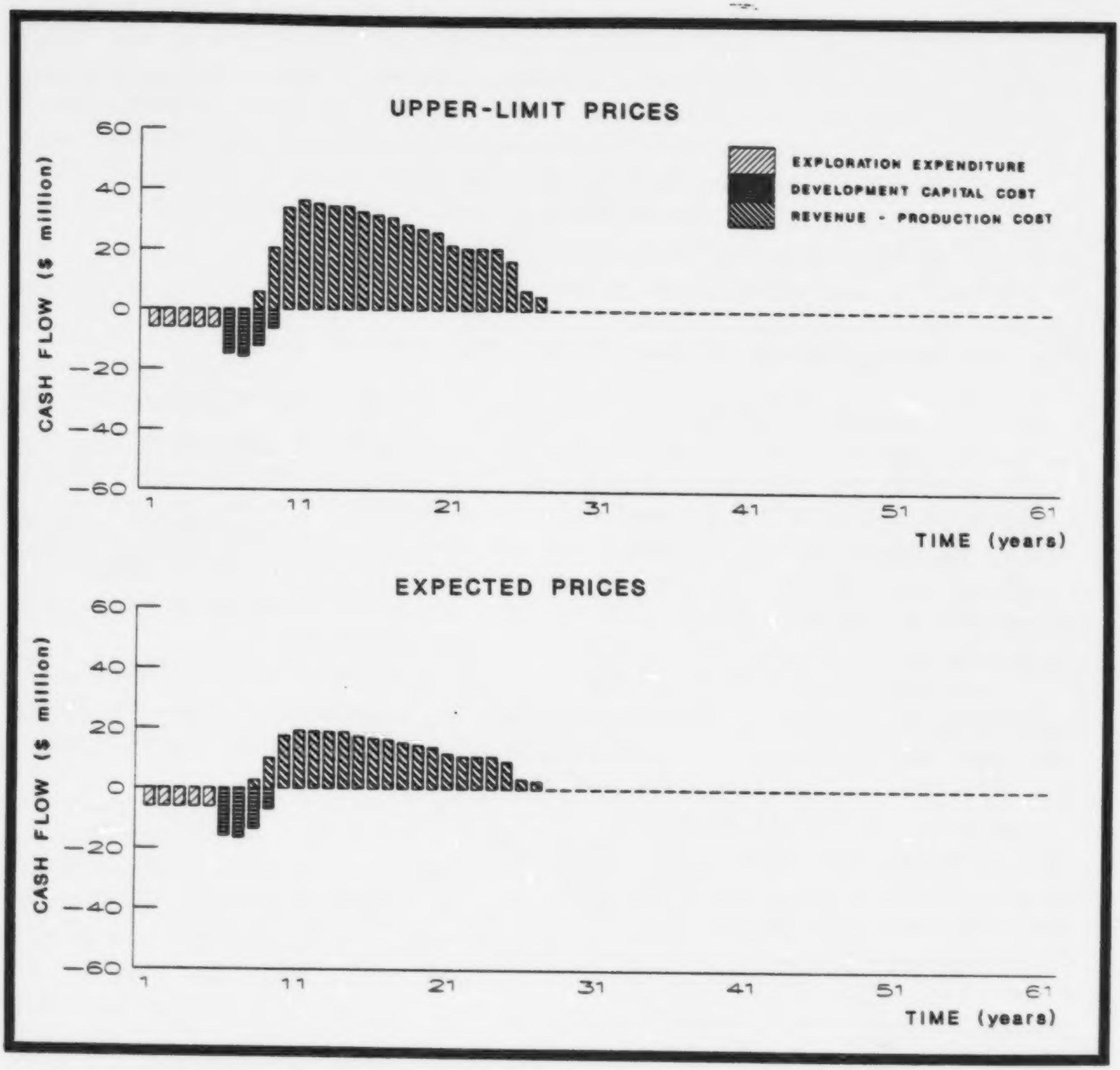


Figure 11. Time Distributions of Average Cash Flows for an Economic Deposit as a Function of Metal Price

These results indicate a high degree of sensitivity of the economics of exploration to metal price uncertainties. None of the Newfoundland deposits would be economic at lower-limit prices. As metal prices increase, there are sharp increases in the number of economic discoveries, in the average return associated with an economic discovery, and in the expected value per economic discovery and expected rate of return. At the same time, higher metal prices reduce the average exploration expenditure and the average time required to discover and delineate an economic deposit.[11] Thus, as discussed in chapter 2, the uncertainty associated with metal price forecasts represents an important risk in corporate planning and government policy analysis. Flexibility should be incorporated in plans and policies to accommodate the resolution of price uncertainties with time.

Variants with Respect to the Annual Exploration Budget

An annual exploration budget rate of $6.0 million, considered to be among the most efficient rates of expenditure (chapter 2), is incorporated in the evaluation carried out in chapter 4. This assumption has a critical bearing on the potential value of mineral supply because it is a determinant of the average time required to discover and delineate an economic deposit. At this rate of expenditure, we estimated that 5 years of exploration are required on average for an economic deposit in Newfoundland.

Assessments of the potential value of base metal and gold supply have also been made for annual exploration budgets of $3.0 million and $9.0 million. The consequences of these variants on the expected value measures are shown in table 13.

As the annual exploration budget is increased, a significant improvement in results is apparent. By reducing the average exploration time required for an economic deposit, the time distribution of negative cash flows is shortened and the time distribution of positive cash flows moves toward the present. Thus, although total exploration expenditures and the number of economic deposits remain constant, the potential value of the mineral supply process is enhanced.

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[11] This is because more discoveries satisfy the definition of "economic deposit"; it is not due to integral change in the exploration process.

Table 13

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND AS A FUNCTION OF THE ANNUAL EXPLORATION BUDGET

	Budget Rate Variant		
Characteristic	$3.0 Million	$6.0 Million	$9.0 Million
Total exploration expenditures ($ million)	321	321	321
Number of economic discoveries	10	10	10
Average exploration expenditure (E,$ million)	21	25	27
Average return (R,$ million)	31	47	54
Expected value (EV,$ million)	10	22	27
Rate of Return (percent)	10	12	13

The average exploration period in Newfoundland is relatively short, about 5 years in the base case (table 5). The sensitivity of expected values to the budget rate would be stronger than that shown in table 13 in situations where the average exploration time required to discover and delineate an economic deposit is longer.

Cost of Capital Variants

A constant money cost of capital of 8 percent is used in the base case to evaluate the economic potential of base metal and gold mining in Newfoundland. To analyze the sensitivity of study results to the cost of capital, assessments of expected value are also made for 5 percent and 12 percent rates. Results are presented in table 14.

Table 14

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND AS A FUNCTION OF THE COST OF CAPITAL

	Cost-of-Capital Variant		
Characteristic	5 Percent	8 Percent	12 Percent
Total exploration expenditures ($ million)	321	321	321
Number of economic discoveries	10	10	10
Average exploration expenditure (E,$ million)	27	25	23
Average return (R,$ million)	81	47	23
Expected value (EV,$ million)	54	22	0
Rate of Return (percent)	12	12	12

Raising the minimum rate-of-return requirement in this case has no effect on reducing the number of economic deposits. As we have already seen (table 11), only one or two of the deposits are in the vicinity of the investment margin and even these projects must have rates of return above 12 percent.

As shown in table 14, the strongest cost-of-capital effect is the reduction in the average return (R). Since the time distribution of revenues for an economic deposit lies further out in the future than the time distribution of development capital cost, heavier discounting resulting from a higher cost of capital reduces discounted revenues more than discounted costs. This lowers the average return and, consequently, the expected value associated with an economic deposit (EV). While the expected rate of return remains unchanged at 12 percent, the rate of return - cost of capital differential narrows appreciably as the hurdle rate is raised from 5 percent to 12 percent.

Summing Up

We have tested the base case findings presented in chapter 4 to realistic ranges of possible future conditions.

The economic potential of base metal and gold supply in Newfoundland is found to be particularly sensitive to future metal prices. None of the Newfoundland deposits would be economic at lower-limit prices. The upside potential appears to be limited. Government policies should have the flexibility to adjust to the resolution of uncertainties associated with this critical market parameter.

The annual exploration budget rate and the cost of capital are also shown to have appreciable impacts on the potential value assessments.

6. NEWFOUNDLAND'S COMPETITIVE STANDING IN THE APPALACHIAN REGION AND IN CANADA

Having examined the economic potential of base metal and gold mining in Newfoundland, the purpose of this chapter is to provide a comparative context. How do the Newfoundland results presented in chapters 4 and 5 compare with similar appraisals for the appalachian region and for Canada? What is Newfoundland's competitive standing in terms of the potential value of mineral supply to society?

Base Metal and Gold Supply

Time distributions of average cash flows for an economic deposit in Newfoundland, the appalachian region, and Canada are compared in figure 12. The undiscounted cash flow characteristics are summarized in table 15. Table 16 presents the associated assessments of expected value criteria.

The average exploration expenditure per economic discovery is remarkably similar in the three cases. The average return associated with the discovery of an economic deposit, however, is found to be much lower in Newfoundland than for the appalachian region and Canada overall. Also, as shown in figure 12 and table 15, the mine production phase is relatively shorter in Newfoundland. What Newfoundland appears to be missing in the mineral discoveries revealed to this point, relative to the rest of Canada, is a multi-billion dollar discovery, the equivalent of a Brunswick 12, Kidd Creek, or Hemlo. This finding is not surprising considering the relatively small sample size of experience in Newfoundland and the scarcity of these exceptional deposits.[12]

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[12] The comparative size characteristics of base metal deposits in Newfoundland and the appalachian region are further examined later in the chapter.

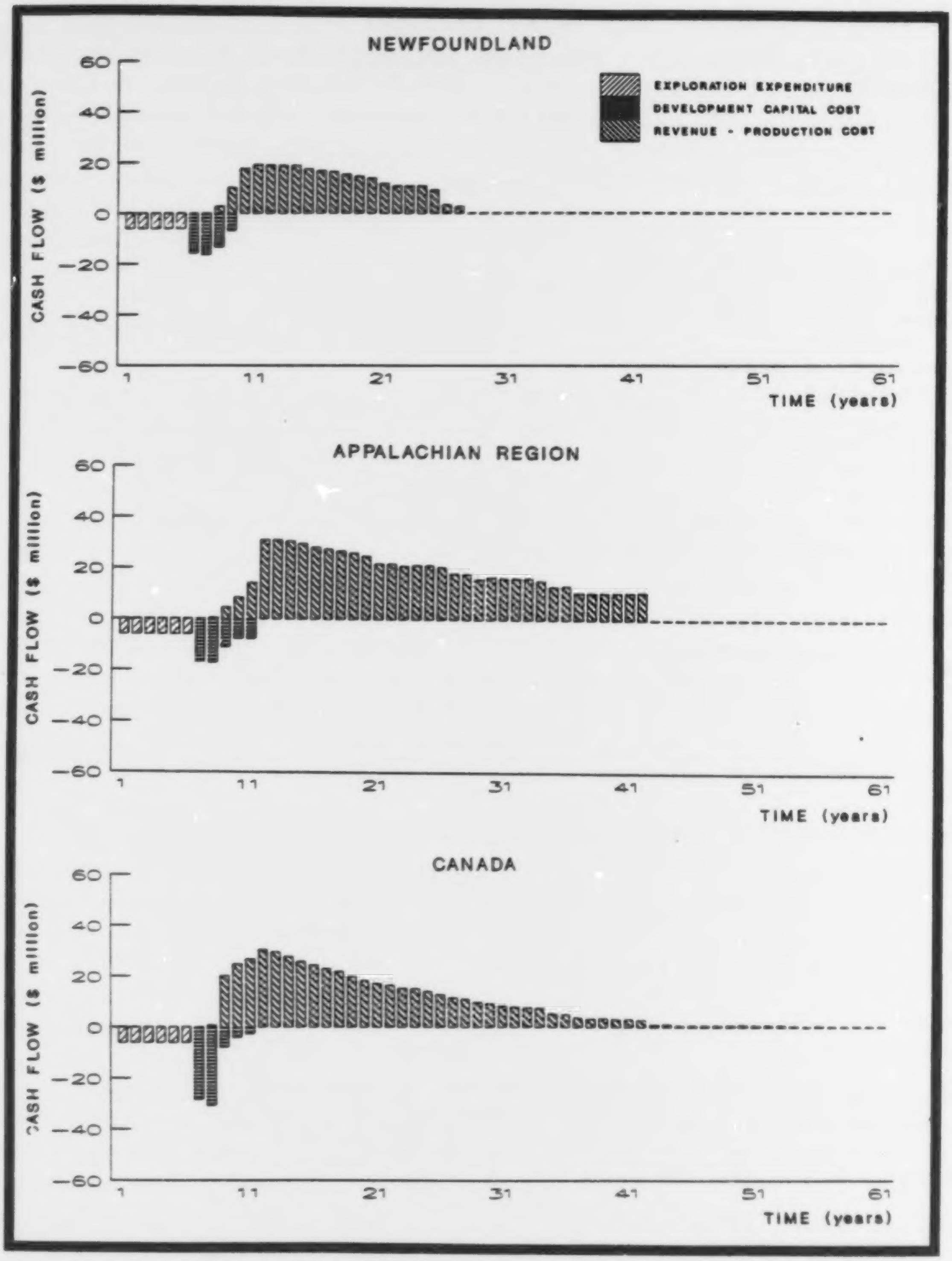

Figure 12. Time Distributions of Average Cash Flows for an Economic Deposit: Newfoundland's Competitive Standing

Table 15

NEWFOUNDLAND'S COMPETITIVE STANDING: AVERAGE CASH FLOW CHARACTERISTICS FOR ECONOMIC DEPOSITS

Characteristic	Newfoundland	Appalachian Region	Canada
Time periods (years):			
Exploration phase	5	6	6
Development phase (maximum)	4	5	5
Production phase (maximum)	20	35	49
Undiscounted values ($ million):			
Revenue	467	1,108	908
Exploration expenditure	32	38	36
Development capital cost	47	61	74
Production cost	213	477	416
Cash flow	175	532	382

Table 16

NEWFOUNDLAND'S COMPETITIVE STANDING: EXPECTED VALUES FOR MINERAL SUPPLY

Characteristic	Newfoundland	Appalachian Region	Canada
Total exploration expenditures ($ mill.)	321	893	7,661
Number of economic discoveries	10	23	209
Average exploration expenditure (E,$ mill.)	25	29	28
Average return (R,$ mill.)	47	94	85
Expected value (EV,$ mill.)	22	65	57
Rate of Return (percent)	12	15	15

Consequently, the expected value per economic deposit in Newfoundland is less than one half that evaluated for the appalachian region and for Canada. The expected rate of return is also somewhat lower. Economic discoveries in Newfoundland during the 1946-85 study period appear to be significantly smaller on average than in the rest of Canada. Nevertheless, the economic potential of base metal and gold supply in the province is positively valued.

Base Metal Supply

Looking more specifically at base metal supply, the undiscounted cash flow values are compared in figure 13 and table 17. Expected value criteria, derived from these appraisals, are shown in table 18.

The average expenditure and the average time required to find and delineate an economic base metal deposit in Newfoundland are found to be less than elsewhere in Canada. This exploration advantage, however, is offset by the small average size of base metal discoveries in the province. The revenue produced by an economic base metal deposit in Newfoundland is shown in table 17 to be less than one third of the average revenue generated by an economic discovery in the appalachian region and in Canada. A multi-billion dollar deposit once again appears to be the missing ingredient.

The expected value per economic discovery and the expected rate of return of base metal supply in Newfoundland while not unattractive are consequently relatively low by broader appalachian region and Canadian standards.

Gold Supply

With respect to gold supply, average cash flow distributions for Newfoundland, the appalachian region, and Canada are summarized in table 17 and compared in figure 14. The associated expected value measures are presented in table 18.

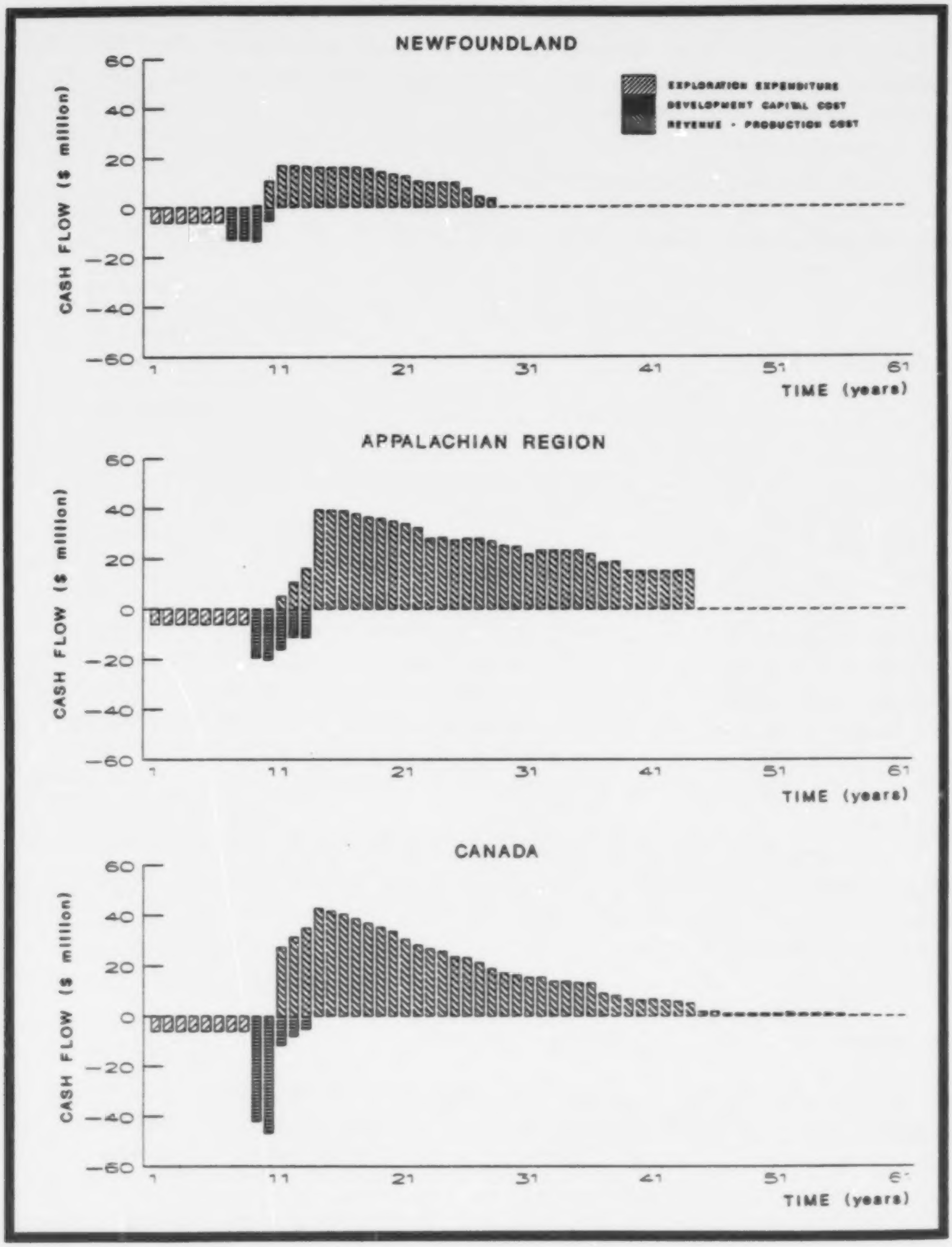

Figure 13. Time Distributions of Average Cash Flows for an Economic Base Metal Deposit: Newfoundland's Competitive Standing

Table 17

NEWFOUNDLAND'S COMPETITIVE STANDING: AVERAGE CASH FLOW CHARACTERISTICS FOR AN ECONOMIC DEPOSIT BY COMMODITY GROUPING ($ million)

Commodity Grouping and Region	Undiscounted Values				
	Revenue	Exploration Expenditure	Development Capital Cost	Production Cost	Cash Flow
Base Metals:					
Newfoundland	415	36	45	178	156
Appalachian Region	1,467	47	78	622	720
Canada	1,429	50	114	681	584
Gold:					
Newfoundland	676	16	57	353	250
Appalachian Region	287	17	21	145	104
Canada	393	23	34	153	183

Table 18

NEWFOUNDLAND'S COMPETITIVE STANDING: EXPECTED VALUES FOR MINERAL SUPPLY BY COMMODITY GROUPING

Commodity Grouping and Region	Number of Economic Discoveries	Average Exploration Expenditure (E,$ mill.)	Average Return (R,$ mill.)	Expected Value (EV,$ mill.)	Rate of Return (%)
Base Metals:					
Newfoundland	8	28	43	15	11
Appalachian Region	16	34	109	75	15
Canada	104	35	100	65	14
Gold:					
Newfoundland	2	14	72	58	17
Appalachian Region	7	14	36	22	15
Canada	105	19	60	41	18

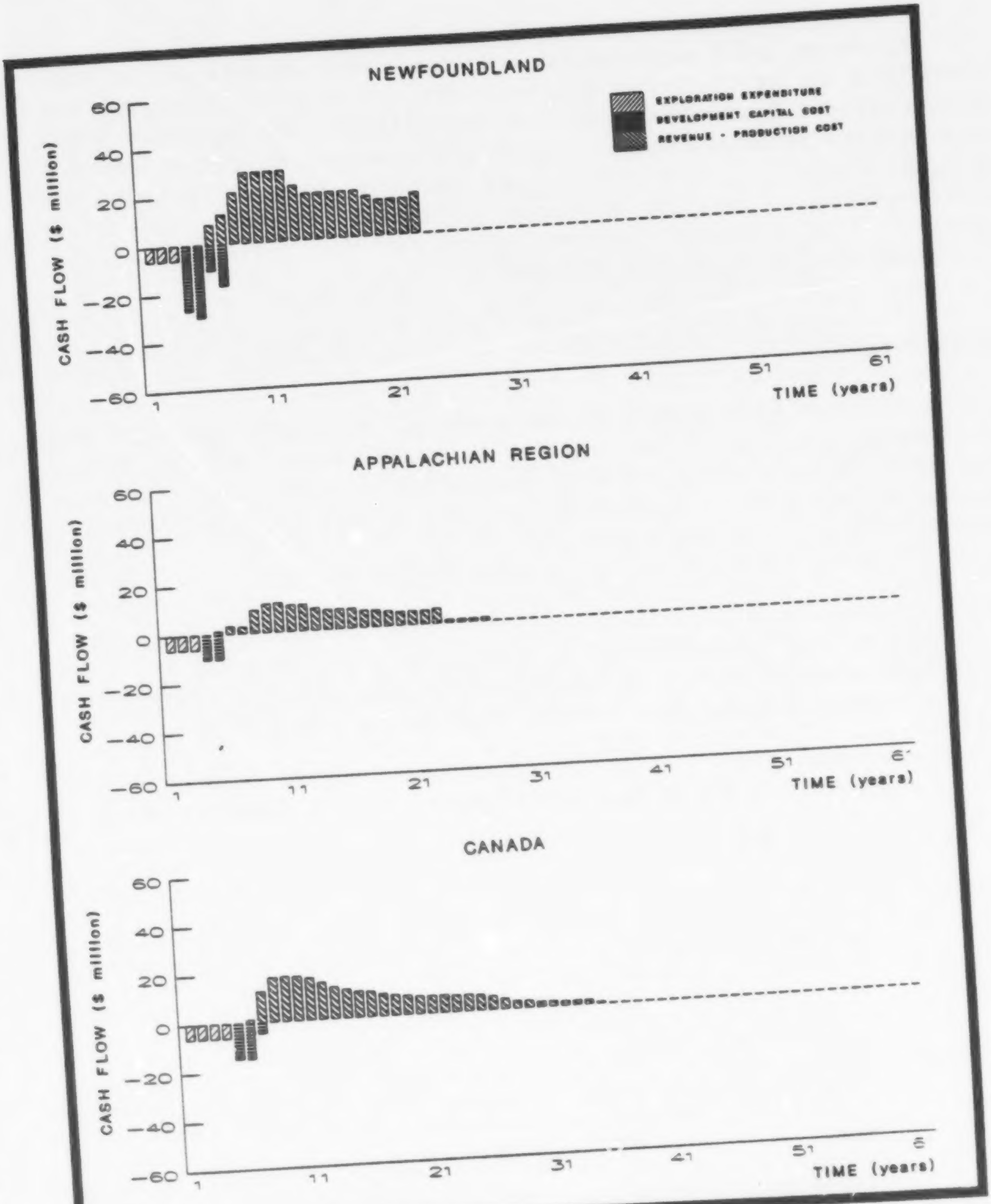

Figure 14. Time Distributions of Average Cash Flows for an Economic Gold Deposit: Newfoundland's Competitive Standing

Although gold exploration and discovery experience in Newfoundland is still quite limited, the comparative findings are encouraging. Average exploration expenditures are somewhat lower and average returns higher than in the appalachian region and for Canada overall. The provincial results mainly reflect the above-average size and economic potential of the Hope Brook deposit. It will be interesting to see how these competitive assessments change in the future.[13]

Time Trends

Table 19 shows time trends in the expected value of base metal and gold supply in Newfoundland, the appalachian region, and Canada for the four decades within the 40-year study period. Similar comparative results are presented in table 20 for base metal mining and in table 21 for gold mining.

The main findings can be summarized as follows:

- a marked deterioration is shown in the economics of base metal supply for Canada overall in the 1966-75 interval and then most significantly in terms of the uneconomic performance assessed for the most recent 1976-85 period;
- base metal potential in the appalachian region is assessed to be uneconomic since the first decade of the time series;

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[13]. Gold exploration and development in Newfoundland is at an early stage relative to the rest of Canada. With the rise of free-market gold prices from the 1970s, the most obvious and attractive targets for gold exploration elsewhere in Canada have been known occurrences in the traditional mining districts. While there are many opportunities of this type, particularly in Quebec, Ontario, and British Columbia, they are being systematically followed up and depleted. With time, there will inevitably be a shift in gold exploration away from the re-evaluation of known occurrences towards primary exploration targets. Newfoundland appears to have a headstart in this respect. Not having a notable gold mining history, exploration programs from the outset of the present era have tended to be of a primary nature.

Table 19

NEWFOUNDLAND'S COMPETITIVE STANDING: TIME TRENDS IN EXPECTED VALUES FOR MINERAL SUPPLY

Region and Time Interval	Total Exploration Expenditures ($ million)	Number of Economic Discoveries	Average Exploration Expenditure (E,$ mill.)	Average Return (R,$ mill.)	Expected Value (EV,$ mill.)	Rate of Return (%)
Newfoundland:						
1946-55	39	3	11	80	69	24
1956-65	81	1	48	18	-30	3
1966-75	110	2	38	11	-27	2
1976-85	91	4	19	62	43	15
Appalachian Region:						
1946-55	101	8	11	300	289	29
1956-65	205	3	44	19	-25	3
1966-75	274	9	51	6	-45	-3
1976-85	313	9	26	37	11	10
Canada:						
1946-55	416	31	12	117	105	23
1956-65	1,233	47	21	134	113	20
1966-75	2,460	43	39	80	41	12
1976-85	3,552	88	30	53	23	12

Table 20

NEWFOUNDLAND'S COMPETITIVE STANDING: TIME TRENDS IN EXPECTED VALUES FOR BASE METAL SUPPLY

Region and Time Interval	Total Exploration Expenditures ($ million)	Number of Economic Discoveries	Average Exploration Expenditure (E,$ mill.)	Average Return (R,$ mill.)	Expected Value (EV,$ mill.)	Rate of Return (%)
Newfoundland:						
1946-55	37	3	11	81	70	25
1956-65	77	1	47	19	-28	3
1966-75	109	2	38	12	-26	2
1976-85	66	2	25	50	25	12
Appalachian Region:						
1946-55	93	8	10	303	293	29
1956-65	190	3	42	20	-22	3
1966-75	263	2	60	4	-56	-2
1976-85	230	3	46	27	-19	5
Canada:						
1946-55	226	20	10	174	164	25
1956-65	1,061	30	27	159	132	19
1966-75	2,165	35	41	81	40	12
1976-85	1,812	19	51	30	-21	5

Table 21

NEWFOUNDLAND'S COMPETITIVE STANDING: TIME TRENDS IN EXPECTED VALUES FOR GOLD SUPPLY

Region and Time Interval	Total Exploration Expenditures ($ million)	Number of Economic Discoveries	Average Exploration Expenditure (E,$ mill.)	Average Return (R,$ mill.)	Expected Value (EV,$ mill.)	Rate of Return (%)
Newfoundland:						
1946-55	2	0	-	-	-	-
1956-65	4	0	-	-	-	-
1966-75	1	0	-	-	-	-
1976-85	25	2	12	75	63	18
Appalachian Region:						
1946-55	8	0	-	-	-	-
1956-65	15	0	-	-	-	-
1966-75	11	1	10	5	-5	-9
1976-85	83	6	12	43	31	18
Canada:						
1946-55	190	11	15	21	6	12
1956-65	172	17	9	70	61	24
1966-75	295	8	28	65	37	15
1976-85	1,740	69	21	62	41	18

- although experience is limited, base metal supply in Newfoundland is shown to have made an encouraging comeback in the most recent decade. This is mainly attributable to the Duck Pond discovery. For the 1976-85 interval, the average exploration expenditure per economic discovery in Newfoundland is about half the Canada-wide finding cost and the average return per economic deposit is much greater than the Canadian average. Consequently, current base metal activities in Newfoundland are found to be economically viable as compared to the uneconomic performance assessed elsewhere in Canada;

- the economics of gold supply appear to be improving with time on a Canada-wide basis (in the appalachian region and Newfoundland, assessments can only be made for the most recent decade, but here, too, the trend appears positive). The time trends presented in table 21 may be somewhat misleading, however, because such a high proportion of the total activity is concentrated in the 1976-85 interval;

- the individual base metal and gold trends tend to cancel out for Canada and in the appalachian region. The expected values for base metal and gold supply combined (shown in table 19), therefore, exhibit relatively uniform time trends. Nevertheless, there is a noticeable deterioration in overall economic performance through the four decades examined;

- in contrast to these broader geographic trends, Newfoundland's competitive standing for the 1976-85 interval is strengthened by the combination of base metal and gold results. The average exploration expenditure per economic discovery is significantly lower than elsewhere in Canada and the average return is higher. Thus, the expected value per economic discovery and expected rate of return assessed for the most recent decade in Newfoundland are superior to those that more generally characterize the appalachian region and Canada.

Return Characteristics of Economic Deposits

Average Returns

The average return characteristics of economic deposits in Newfoundland, the appalachian region and Canada as viewed from the start of development are compared in table 22 for base metal and gold deposits taken together, and in table 23 for base metal and gold deposits as separate groupings.

Table 22

NEWFOUNDLAND'S COMPETITIVE STANDING: EXPECTED VALUES FOR MINE DEVELOPMENT

Characteristic	Newfoundland	Appalachian Region	Canada
Total revenue ($ million)	467	1,088	978
Net present value ($ million)	71	153	135
Rate of return (percent)	25	31	32

These results confirm some of the main points that arose earlier in the comparative long-term supply assessments:

- economic base metal deposits in Newfoundland are on average only about one third the size of deposits elsewhere in Canada. The potential profitability of the province's deposits, however, is shown to be comparable;
- economic gold deposits in Newfoundland, on the other hand, are found to be larger but less profitable than in the appalachian region and Canada generally. The gold exploration and discovery experience in Newfoundland, however, is too limited for this comparative finding to be of long-term significance;

Table 23

NEWFOUNDLAND'S COMPETITIVE STANDING: EXPECTED VALUES FOR MINE DEVELOPMENT BY COMMODITY GROUPING

Commodity Grouping and Region	Total Revenue ($ million)	Net Present Value ($ million)	Rate of Return (percent)
Base Metals:			
Newfoundland	465	67	27
Appalachian Region	1,355	200	31
Canada	1,434	190	29
Gold:			
Newfoundland	676	88	22
Appalachian Region	287	45	31
Canada	393	80	41

- combining the return characteristics for base metal and gold deposits, table 22 shows that economic discoveries in Newfoundland to date are about half the size and somewhat less profitable on average than elsewhere in Canada. The expected values associated with Newfoundland's economic deposits are nevertheless economically attractive;
- based on the Canada-wide appraisals, economic gold deposits tend to be about one quarter the size but more profitable than the economic base metal deposits;
- in Newfoundland, based on a very small sample size, the base metal - gold deposit comparison contradicts the overall Canadian finding. As shown in table 23, Newfoundland's economic base metal deposits are smaller but more profitable on average than the two economic gold deposits.

Variability of Returns

Cumulative distributions of total revenue, net present value, and rate of return for economic deposits in Newfoundland, the appalachian region and Canada are compared using key statistics in table 24 for base metal and gold deposits together, and in table 25 for base metal deposits (there are insufficient data to consider the variability of gold deposit returns in Newfoundland and the appalachian region). Besides further illustrating the high degree of variability in return characteristics that occurs among economic deposits throughout Canada, these comparative statistics help explain earlier findings as follows:

- the large size of base metal deposits in the appalachian region and Canada relative to Newfoundland is mainly attributable to the presence of multi-billion dollar discoveries, including Kidd Creek, Brunswick 12, Horne, Geco, Flin Flon, Sullivan, and several economic porphyry deposits. Note that the median statistics for total revenue in table 25 are quite similar as compared to the three-fold difference in mean values. The multi-billion dollar discoveries skew the total revenue distributions for the appalachian region and Canada as illustrated by the high upper-decile and upper-quartile statistics. This explains why the mean values in these cases are in the vicinity of the upper-quartile statistics;

- with respect to the rate of return for economic base metal deposits, the three sets of statistics are remarkably similar;

- the combination of total revenue and rate of return distribution characteristics explain the comparative net present value results for base metal deposits in table 25;

- the main differences in the return characteristics for the combination of economic base metal and gold deposits in table 24 are with respect to the mean and upper-decile statistics for Newfoundland compared to the appalachian region and Canada-wide values. The missing feature in Newfoundland is once again found to be a multi-billion dollar discovery. Perhaps Hope Brook and/or Duck Pond as a result of continued exploration success, will provide this important ingredient.

Table 24

NEWFOUNDLAND'S COMPETITIVE STANDING: VARIABILITY OF THE RETURN FOR ECONOMIC DEPOSITS

	Total Revenue ($ million)			Net Present Value ($ million)			Rate of Return (percent)		
	Newfoundland	Appalachian Region	Canada	Newfoundland	Appalachian Region	Canada	Newfoundland	Appalachian Region	Canada
Upper decile	1,184	2,826	2,053	281	352	312	65	73	74
Upper quartile	836	1,067	799	140	143	113	40	54	49
Mean (average)	465	1,088	978	91	148	156	32	37	40
Median	377	378	289	52	64	46	25	32	31
Lower quartile	181	158	139	24	22	20	18	17	20
Lower decile	43	39	68	3	3	7	14	12	13

Notes: based on expected metal prices; total revenue is evaluated at the minesite; net present value is determined at the start of development using an 8-percent discount rate; includes economic base metal deposits discovered before 1946.

Table 25

NEWFOUNDLAND'S COMPETITIVE STANDING: VARIABILITY OF THE RETURN FOR ECONOMIC BASE METAL DEPOSITS

	Total Revenue ($ million)			Net Present Value ($ million)			Rate of Return (percent)		
	Newfoundland	Appalachian Region	Canada	Newfoundland	Appalachian Region	Canada	Newfoundland	Appalachian Region	Canada
Upper decile	1,194	2,886	3,429	313	396	471	68	57	70
Upper quartile	583	1,155	1,604	147	183	179	42	41	44
Mean (average)	465	1,355	1,434	97	183	215	32	31	34
Median	377	536	458	52	70	63	25	28	27
Lower quartile	140	222	222	12	35	29	16	16	16
Lower decile	40	56	114	3	5	9	13	12	12

Notes: based on expected metal prices; total revenue is evaluated at the minesite; net present value is determined at the start of development using an 8-percent discount rate; includes economic base metal deposits discovered before 1946.

Comparative Endowment and Return Characteristics for Deposits Discovered Before and During the Study Period

Considering the complete timeframe of historical experience, table 26 compares average endowment characteristics of possible economic base metal deposits discovered before and during the 1946-85 study period. No significant trend is apparent for Newfoundland. Discoveries during the study period are similar on average to the deposits found prior to 1946. Results for the appalachian region are influenced by the Copper Mountain and Needle Mountain deposits, pre-1946 discoveries in the Gaspe region. For Canada overall, the 303 base metal discoveries made during the 1946-85 period are typically very much larger than the 102 deposits discovered before 1946. This difference primarily reflects the impact of huge porphyry copper and copper-molybdenum deposits discovered in British Columbia in the 1960s.

Broad trends in average return characteristics for economic base metal deposits discovered before and during the study period are shown in table 27. Economic base metal deposits found in Newfoundland prior to 1946 are shown to be somewhat larger and more profitable on average than the more recent discoveries.[14] In the case of the appalachian region averages, economic discoveries during the 1946-85 period are larger (because of the influence of the Brunswick 12 deposit) but somewhat less profitable than the pre-1946 finds. Economic base metal deposits discovered in Canada during the study period are shown in table 27 to be of similar size but less profitable, on average, than the pre-1946 discoveries. The influence of the porphyry deposits is more modest here than in table 26 because relatively few of these discoveries would be economic for the current outlook conditions used in the appraisal.

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[14]. The three pre-1946 economic discoveries are relatively large and high grade deposits in the Buchans district.

Table 26

NEWFOUNDLAND'S COMPETITIVE STANDING: TIME TRENDS IN AVERAGE BASE METAL ENDOWMENT CHARACTERISTICS FOR POSSIBLE ECONOMIC DISCOVERIES

	Discoveries in Newfoundland		Appalachian Region Discoveries		Discoveries in Canada	
	Pre-1946	1946-85	Pre-1946	1946-85	Pre-1946	1946-85
Possible economic discoveries (number)	11	16	19	42	102	303
Recoverable ore reserves (t million)	2	2	15	9	9	30
Annual mill capacity (t thousand)	211	217	603	508	461	1,342
Productive mine life (years)	9	10	11	11	10	12
Development capital cost ($ million)	36	38	45	52	46	84
Unit production cost ($/t)	75	62	74	59	91	73
Unit revenue ($/t)	106	89	87	69	108	67
Total revenue ($ million)	222	233	319	632	527	671

Table 27

NEWFOUNDLAND'S COMPETITIVE STANDING: TIME TRENDS IN AVERAGE BASE METAL RETURN CHARACTERISTICS FOR ECONOMIC DISCOVERIES

	Discoveries in Newfoundland		Appalachian Region Discoveries		Discoveries in Canada	
	Pre-1946	1946-85	Pre-1946	1946-85	Pre-1946	1946-85
Economic discoveries (number)	3	8	5	16	31	104
Total Revenue ($ million)	598	415	996	1,467	1,446	1,430
Net Present Value ($ million)	178	67	127	201	300	190
Rate of Return (percent)	48	27	34	30	43	32

Comparative Size of Base Metal Deposits

Economic base metal discoveries in Newfoundland are found to be much smaller on average than those made elsewhere in the appalachian region and Canada. We have previously commented that the missing ingredient to date in Newfoundland appears to be one of the rare multi-billion dollar deposits.

This point is further examined by testing the sensitivity of the comparative average size of economic base metal deposits in Newfoundland and the appalachian region to:

- treating all of the Buchans deposits as a single discovery;
- hypothetically removing the Brunswick 12 deposit from the appalachian region.

Since the single Buchans deposit is classified as a pre-1946 discovery, all base metal deposits discovered to 1985 are included in the evaluation and comparison which follows.

Given expected metal price projections, the total minesite revenue produced by the combined Buchans deposit is estimated to be $2.9 billion.

The mean size of an economic base metal deposit in Newfoundland would under these assumed circumstances more than double from $465 million to $971 million. Also, the appalachian region average would be enhanced from $1355 million to $1880 million. Thus, the relative size of an economic deposit in Newfoundland would increase from about one-third to about one-half of the appalachian region standard.

If the Brunswick 12 discovery is hypothetically removed from the appalachian region record, the average deposit size decreases from a total minesite revenue of $1355 million to $791 million. In this case, assuming the Buchans deposits are treated individually, the relative size of an economic base metal deposit in Newfoundland would be more than one-half the appalachian region average ($465 million as compared to $791 million).

If the two specified changes are made together, the average deposit size would to be similar - $971 million for Newfoundland as compared to $1111 million for the appalachian region.

These sensitivity analysis results show that there is really nothing unusual about the size distribution of base metal deposits in Newfoundland. The differences assessed mainly appear attributable to:

- how individual mineral deposits have been defined for evaluation purposes;
- the difficulty of obtaining a representative sample of extremely large deposits within a relatively small overall sample size of discovery experience.

Summing Up

While the economic potential of base metal and gold supply in Newfoundland is positively valued, the expected value indicators assessed are significantly lower than those which more broadly characterize the appalachian region and Canada. The exploration expenditures required to discover and delineate an economic deposit are similar in the three cases. However, economic base metal deposits discovered in Newfoundland during the 1946-85 study period are found to be significantly smaller on average than those discovered elsewhere in Canada. The missing ingredient to date appears to be one of the rare multi-billion dollar deposits. Further examination shows that there is nothing unusual about the size characteristics of base metal deposits in Newfoundland. The size differences assessed are mainly attributable to the difficulty of obtaining a representative weighting for extremely large deposits within the relatively small sample size of Newfoundland discoveries.

Base metal supply in Newfoundland is shown to have made an encouraging comeback in the most recent decade analyzed (1976-85). This is mainly attributable to the Duck Pond discovery. The positive provincial trend contrasts with the marked deterioration in base metal performance which has characterized the rest of Canada since 1966-75. For the 1976-85 decade, the average exploration expenditure per economic discovery in Newfoundland is about half the Canada-wide finding cost, and the average return per economic deposit is considerably higher than the Canadian norm.

The potential value of gold supply appears to be improving with time in Newfoundland, the appalachian region, and Canada. These time trends are somewhat tenuous, however, because so much of the activity is concentrated in the most recent decade.

7. MINING TAXATION CONSIDERATIONS

Chapters 4-6 have presented and analyzed results for the potential, before-tax value of base metal and gold supply with particular reference to Newfoundland. It is now appropriate to evaluate what these assessments mean in terms of after-tax incentive to the mining company contemplating investment in mineral exploration and mine development.

For this purpose, the income and mining taxation systems operative in Newfoundland and more generally in Canada during 1987 are imposed on the potential value assessments, and measures of investment incentive are derived.[15] A detailed description of the taxation systems applied is given in appendix VI.[16]

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[15]. The evaluation of taxation effects in Newfoundland is based on the applicable general legislation. No consideration is given to special royalty agreements between mining companies and the Newfoundland government which in some cases override the general policies. Also, we have not taken the possible effect of taxation revenues on Newfoundland equalization payments into account.

[16]. Three types of taxation payment are included in the analysis: federal corporate income tax, provincial corporate income tax, and provincial mining tax and royalty. These profit-based government levies are only part of the total tax picture. The study does not consider such non-profit taxes and government mandated costs as sales tax, fuel tax, corporation capital tax, workers' compensation payments, and property tax. The effect of these charges is examined in Effects of Location on Competitive Position of Mineral Exploration and Development Opportunities in Canada, B.W. Mackenzie, D.W. Davis, and M.L. Bilodeau, working paper no. 35, Centre for Resource Studies, Queen's University, 1986.

Taxation Assumptions

Inflation

The existence of inflation complicates the evaluation of mining taxation effects. This is the result of two factors. First, the write-off of capital costs for tax purposes is only permitted over future periods of time. Tax allowances are taken against the current money income realized in those future time periods. Second, the amount which can be written off is limited to the actual capital costs incurred. Consequently, inflation reduces the real constant-money benefits of tax write-offs. Thus, inflation reduces investment incentive and increases government tax revenues in real terms. The higher the rate of inflation, the stronger these effects will be.

It is therefore important to consider inflation when assessing after-tax incentives for exploration and development. A 5-percent per year general rate of inflation is assumed here for this purpose.

Exploration Expenditures

The mining taxation systems outlined in appendix VI generally permit the "expensing" of exploration expenditures against current income as they are incurred.[17] This study does not consider the carry-forward of exploration expenditures for write-off against production income from economic deposits. Larger organizations are assumed to have sufficient income from other sources to be able to deduct exploration expenditures as they are incurred, receiving tax credits at the prevailing rate of taxation. Smaller enterprises are assumed to have no existing income and, therefore, receive no direct tax benefit from their exploration expenditures. An equivalent tax credit can, however, be realized by the investors as a result of flow-through share policy.

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[17]. When we say that exploration expenditures are "expensed" for tax purposes, we mean that they are deducted from a company's income in the year expended for purposes of computing taxable income. This, for example, is the same way that operating costs are treated for tax purposes.

The "base case" for the tax assessments assumes that 100 percent of the exploration expenditures are expensed for tax purposes. The effect of a 0-percent expensing variant is also considered. The rates that are used to calculate the tax credits realized on exploration expenditures are given at the end of appendix VI.

Development and Production Phases

Mining taxation allowances for the development and production phases can, generally speaking, be taken either on an individual project basis or on an integrated company basis. With the individual project basis of taxation, allowances for the development and production phases may only be taken against production income from the project. Thus, it is assumed that the mining company has no existing source of income. By "integrated company" we mean a mining company with existing sources of income from other projects. With the integrated company basis of taxation, allowances for the development and production phases may be written off as rapidly as possible against this existing income stream. The tax credits realized on an integrated company basis will, therefore, be more immediate than on an individual project basis. The "base case" assumes that taxation is on an individual project basis. The integrated company basis of taxation is considered as a variant.

Base Case Results

The after-tax base case conditions, to which other results are compared, include those already specified in chapter 4 for the assessment of potential value. In addition, the following taxation conditions, discussed above, are embodied in the base case:

- 1987 Newfoundland and Canadian mining taxation systems;
- general rate of inflation of 5 percent;
- 100 percent of the exploration expenditures expensed for tax purposes;
- individual project basis of taxation for development and production phases.

For after-tax base case conditions, the number of economic deposits remains unchanged at 10. The cost and revenue characteristics of these deposits are used to assess the time distribution of average after-tax cash flows for an economic deposit. These average cash flows are presented in figure 15 and summarized in table 28. Thus, on average, the net after-tax cash flow associated with an economic deposit is $96 million as compared to $175 million before tax.

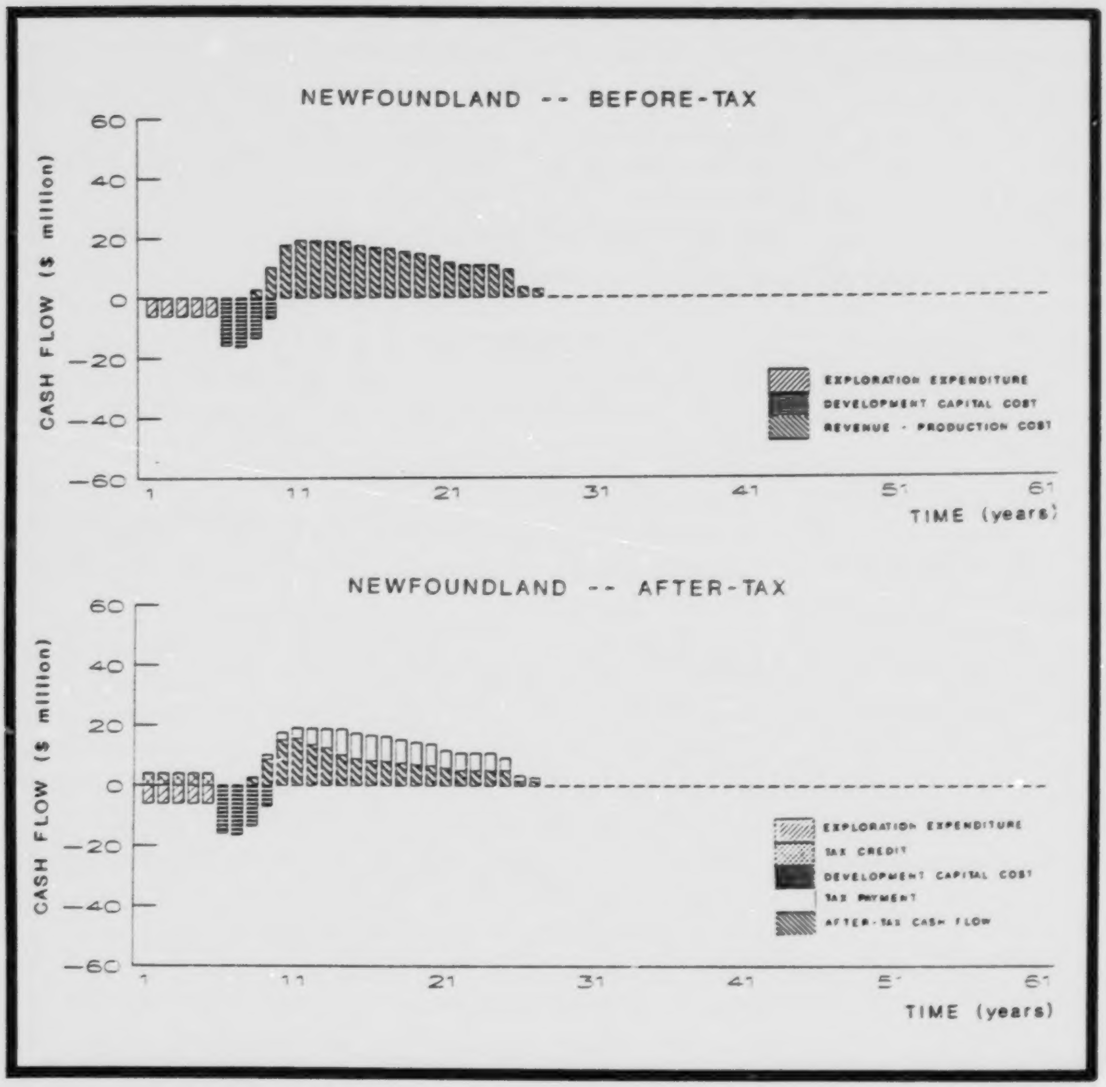

Figure 15. After-Tax Time Distribution of Average Cash Flows for an Economic Deposit: Base Case Conditions

Table 28

AVERAGE AFTER-TAX CASH FLOW CHARACTERISTICS FOR AN ECONOMIC DEPOSIT UNDER BASE CASE CONDITIONS

Characteristic	Newfoundland Potential Value	 After-Tax Value
Time periods (year):		
Exploration phase	5	5
Development phase (maximum)	4	4
Production phase (maximum)	20	20
Undiscounted values ($ million):		
Revenue	467	467
Exploration expenditure	32	32
Development capital cost	47	47
Production cost	213	213
Tax and royalty payments		83
Cash flow	175	92

Table 29 presents after-tax expected value assessments for the base case conditions. The average exploration expenditure required to find and delineate an economic deposit, $25 million potentially at the start of exploration is reduced by the tax credits received to $9 million on an after-tax basis. However, the average return from an economic deposit is also reduced from $47 million to $20 million. The $27 million difference in returns is the discounted equivalent of the time distribution of federal and Newfoundland taxation payments portrayed in figure 15. Thus, the after-tax expected value of base metal and gold exploration in Newfoundland per economic discovery is (20-9) = $11 million. The corresponding expected after-tax rate of return is shown in table 29 to remain unchanged at 12 percent. The rate of return is maintained at its before-tax level because at this discount rate the present value of exploration tax credits is of the same magnitude as the present value of tax liabilities incurred during production.

Table 29

AFTER-TAX EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND UNDER BASE CASE CONDITIONS

Characteristic	Newfoundland Potential Value	Newfoundland After-Tax Value
Number of economic discoveries	10	10
Average exploration expenditure (E,$ million)	25	9
Average return (R,$ million)	47	20
Expected Value (EV,$ million)	22	11
Rate of return (percent)	12	12
Share of actual value (percent):		
Mining company's		52
Governments'		48

The level or incidence of taxation can be illustrated by the relationship between the present value of the net tax payments and the present value of after-tax cash flows, both discounted at the 8-percent cost of capital. The sum of these two components is termed the "actual value" of mineral supply as compared to the "potential value" assessed in chapters 4-6.

In Newfoundland under base case conditions, government taxation payments are shown in table 29 to represent about 48 percent of the actual value of mineral supply. Consequently, mining companies receive 52 percent of the actual value realized in the form of after-tax cash flows.

Turning to the evaluation of return characteristics in the medium term as viewed from the start of development, after-tax assessments for the development and production phases of the cash flow distribution illustrated in figure 15 are shown in table 30. The expected net present value per economic deposit is reduced from $71 million to $30 million, and the expected rate of return falls from 25 percent to 18 percent. The mining company's share of the actual value realized is 42 percent. The Newfoundland and federal governments receive the remaining 58 percent in taxation payments. The mining company's share at the start of development is lower than its share at the start of exploration (42 perent versus the 52 percent shown in table 29) because, at the mine development stage, the exploration-phase tax credits received, like the exploration expenditures incurred, are no longer a relevant consideration for evaluation purposes.

Table 30

AFTER-TAX EXPECTED VALUES FOR MINE DEVELOPMENT IN NEWFOUNDLAND

	Newfoundland	
Characteristic	Potential Value	After-Tax Value
Total Revenue ($ million)	467	467
Net present value ($ million)	71	30
Rate of Return (percent)	25	18
Share of actual value (percent):		
Mining company's		42
Governments'		58

Metal Price Variants

The after-tax assessment of expected values for base metal and gold supply in Newfoundland as a function of metal price is summarized in table 31. As in the before-tax appraisal, there would be no economic deposits at lower-limit prices. The enhanced expected values at upper-limit prices are somewhat eroded by the marginal increase in the incidence of taxation payments. As metal prices are raised from expected to upper-limit levels, the mining company's share of the actual value is reduced from 52 percent to 51 percent.

Newfoundland's Competitive Standing

After-tax expected values for base metal and gold exploration in Newfoundland, the appalachian region and Canada are compared in table 32. Similarly, the after-tax economics of mine development are presented in table 33.

As viewed from the start of exploration (table 32), Newfoundland's competitive position remains approximately the same on an after-tax basis as before tax. The mining companies' share of the actual value realized is marginally higher than for the appalachian region and marginally lower than for the Canada-wide result.

As viewed from the start of development (table 33), Newfoundland's competitive position is found to weaken after tax. The mining companies' share is 42 percent as compared with average shares of 46 percent in the appalachian region and 48 percent for Canada overall. The difference in relative shares between the results in tables 32 and 33 is attributable to the relatively large tax credits realized on exploration expenditures with the tax system in Newfoundland, reflecting a relatively high overall tax rate.

Tax Write-Off Variants

The effects of the following three sets of exploration and development tax write-off provisions are considered here.

Table 31

AFTER-TAX EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND AS A FUNCTION OF METAL PRICE

	Lower-Limit Prices		Expected Prices		Upper-Limit Prices	
	Potential Value	After-Tax Value	Potential Value	After-Tax Value	Potential Value	After-Tax Value
Number of economic discoveries	0	0	10	10	11	11
Average exploration expenditure (E,$ million)	-	-	25	9	23	8
Average return (R,$ million)	-	-	47	20	120	56
Expected value (EV,$ million)	-	-	22	11	97	48
Rate of return (%)	-	-	12	12	22	22
Share of actual value (percent):						
Mining company's	-	-		52		51
Governments'	-	-		48		49

Table 32

NEWFOUNDLAND'S COMPETITIVE STANDING: AFTER-TAX EXPECTED VALUES FOR MINERAL EXPLORATION

	Lower-Limit Prices		Expected Prices		Upper-Limit Prices	
	Potential Value	After-Tax Value	Potential Value	After-Tax Value	Potential Value	After-Tax Value
Number of economic discoveries	10	10	23	22	209	194
Average exploration expenditure (E,$ million)	25	9	29	10	28	11
Average return (R,$ million)	47	20	94	43	85	41
Expected value (EV,$ million)	22	11	65	33	57	30
Rate of return (%)	12	12	15	15	15	15
Share of actual value (percent):						
Mining company's		52		51		53
Governments'		48		49		47

Table 33

NEWFOUNDLAND'S COMPETITIVE STANDING: AFTER-TAX EXPECTED VALUES FOR MINE DEVELOPMENT

	Lower-Limit Prices		Expected Prices		Upper-Limit Prices	
	Potential Value	After-Tax Value	Potential Value	After-Tax Value	Potential Value	After-Tax Value
Net present value	71	30	153	72	135	68
Rate of return (%)	25	18	31	23	32	25
Share of actual value (percent):						
Mining company's		42		46		48
Governments'		58		54		52

1. Base Case Conditions: 100-percent expensing of exploration expenditures; individual project basis of taxation.
2. Tax Variant 1: 0-percent expensing of exploration expenditures; individual project basis of taxation.
3. Tax Variant 2: 100-percent expensing of exploration expenditures; integrated company basis of taxation.

Expected value assessments are presented in table 34. The ability to expense exploration costs for tax purposes is of great benefit, as illustrated by differences between the base case and variant 1 in the average after-tax exploration expenditures required to find and delineate an economic deposit and by the company/government shares of the actual value realized. Without this incentive (variant 1), the after-tax expected values would in fact be uneconomic and the mining company's share of the actual value realized would be negative. The integrated company tax basis (variant 2) is shown in table 34 to increase the after-tax expected values significantly compared to results for the individual project basis of taxation assumed in the base case, raising the mining company's share of the actual value from 52 percent to 70 percent.

Generally, there is a marked inequality between the traditional tax treatment of junior exploration enterprises (variant 1) and established mining companies (variant 2), as shown in table 34 by the comparative expected values per economic discovery and expected rates of return. A desirable feature of the federal government's flow-through share policy is that it effectively closes this discriminatory gap.

Inter-Provincial Comparison

In order to compare the effects of taxation in Newfoundland with that which characterizes the other Canadian provinces and territories, the 1987 tax system in each jurisdiction (appendix VI) is applied in turn to Newfoundland before-tax mineral exploration potential. Results are summarized in table 35.

Newfoundland's taxation policies tend to be on the onerous side of the spectrum of inter-provincial assessments presented:

Table 34

AFTER-TAX EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND AS A FUNCTION OF TAX WRITE-OFF VARIANTS

	Newfoundland	
Category and Tax Variant	Potential Value	After-Tax Value
Number of economic discoveries	10	
Base case		10
Tax variant 1		10
Tax variant 2		10
Average exploration expenditure (E, $ million)	25	
Base case		9
Tax variant 1		25
Tax variant 2		9
Average return (R, $ million)	47	
Base case		20
Tax variant 1		20
Tax variant 2		24
Expected value (EV, $ million)	22	
Base case		11
Tax variant 1		-5
Tax variant 2		15
Rate of return (percent)	12	
Base case		12
Tax variant 1		7
Tax variant 2		14
Mining company/government shares (percent)		
Base case		52/48
Tax variant 1		-24/124
Tax variant 2		70/30

Table 35

NEWFOUNDLAND'S COMPETITIVE STANDING: INTER-PROVINCIAL COMPARISON OF AFTER-TAX VALUES

Taxation System	Number of Economic Discoveries	Exploration Expenditure (E,$ mill)	Average Return (R,$ mill)	Expected Value (EV,$ mill)	Rate of Return (%)	Share of Actual Value (%)	
						Mining Company's	Governments'
Potential values	10	25	47	22	12		
After-tax values:							
Newfoundland	10	9	20	11	12	52	48
Nova Scotia	10	9	23	14	13	66	34
New Brunswick	10	7	21	14	13	63	37
Quebec	9	12	23	11	11	52	48
Ontario	10	9	22	13	12	57	43
Manitoba	10	8	19	11	12	48	52
Saskatchewan	8	11	22	11	11	52	48
Alberta	10	11	27	16	13	72	28
British Columbia	9	9	18	9	11	40	60
Northwest Territories	10	13	27	14	12	63	37
Yukon Territory	10	13	26	13	12	61	39

- the number of discoveries which would be economic after tax varies from 8 to 10, including 10 for Newfoundland and seven other jurisdictions;
- the average after-tax exploration expenditure per economic discovery ranges from $7 million to $13 million, including $9 million for Newfoundland;
- the average after-tax return from an economic deposit varies from $18 million to $27 million, including $20 million for Newfoundland;
- the after-tax expected value of exploration per economic discovery ranges from $9 million to $16 million, including $11 million for Newfoundland and three other provinces;
- the after-tax rate of return on investment varies from 11 percent to 13 percent, including 12 percent for Newfoundland;
- the mining companies' share of the actual value realized from mineral exploration ranges from 40 percent to 72 percent, including 52 percent for Newfoundland;
- conversely, the governments' share varies from 28 percent to 60 percent, including 48 percent for Newfoundland.

The comparative incidence of taxation in the eleven jurisdictions can be measured by the present value of total tax payments, expressing payments in the ten other jurisdictions relative to an index of 100 for the present value of total taxes associated with the policies currently operative in Newfoundland. The resulting tax indices are presented in figure 16. The total level of mining taxation in Newfoundland is found to be:

- significantly lower than in British Columbia;
- about the same as in Quebec, Manitoba, and Saskatchewan;
- significantly higher than in Nova Scotia, New Brunswick, Ontario, Alberta, the Northwest Territories, and the Yukon.

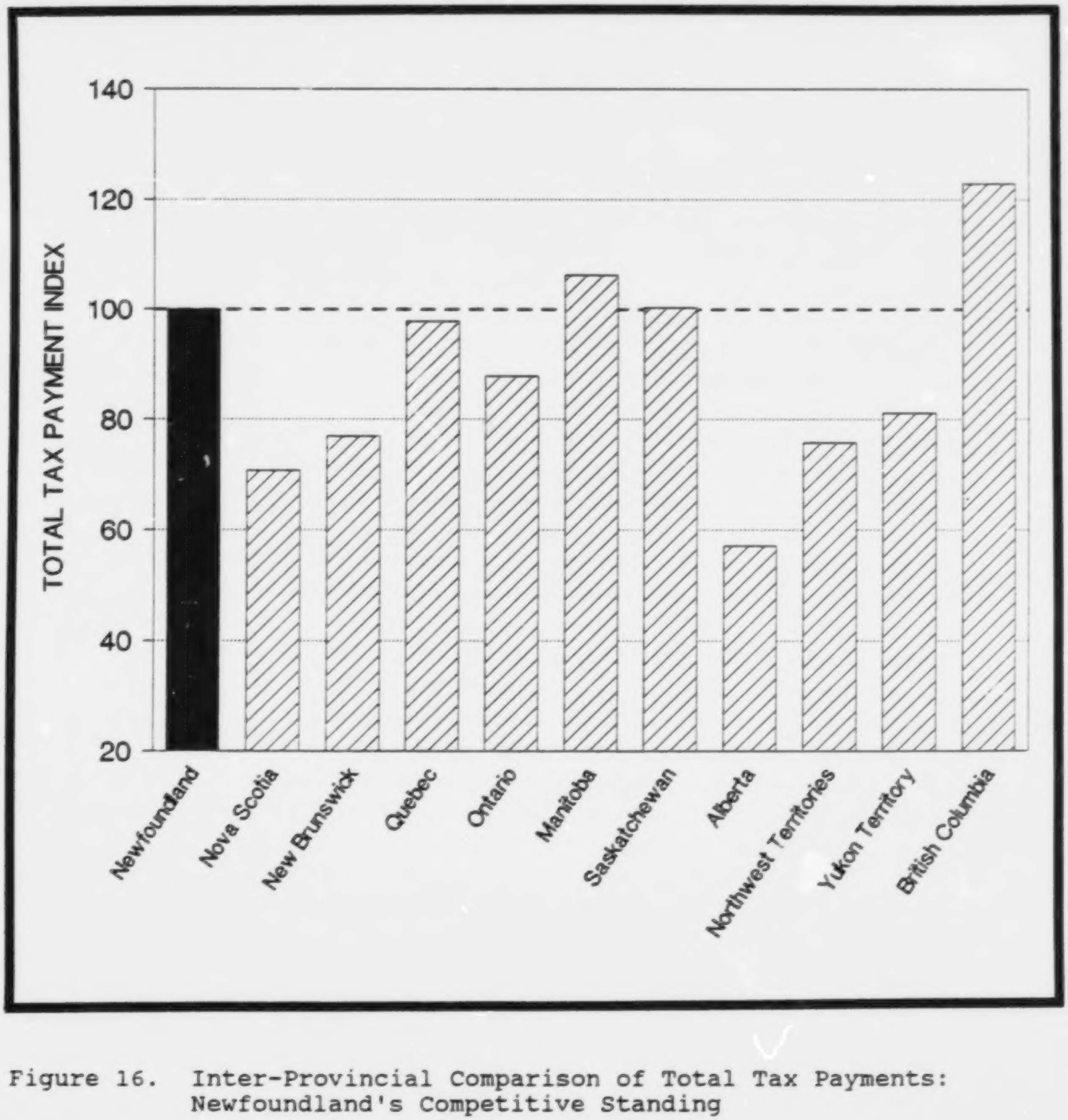

Figure 16. Inter-Provincial Comparison of Total Tax Payments: Newfoundland's Competitive Standing

Newfoundland's competitive tax position for each of the three components which make up this overall comparison - federal corporate income tax, provincial corporate income tax, and provincial mining tax - is illustrated in figure 17. The main findings can be summarized as follows:

- federal corporate income tax payments in the atlantic provinces are much lower than in the other jurisdictions because of the relief provided by the investment tax credit;[18]
- Newfoundland corporate income tax payments are shown in figure 17 to be significantly lower than in British Columbia and Ontario and, on the other hand, higher than in the other eight jurisdictions;
- the incidence of Newfoundland mining taxation is high, ranking with Quebec as the most burdensome in Canada. There appears to be two main reasons for this. First, the depreciation rate for Newfoundland mining tax, straight line over mine life, tends to be low compared to the rates allowed in other provinces and territories (except for productive mine lives of less than four or five years). Second, unlike other Canadian jurisdictions, the processing allowance for Newfoundland mining tax is not subject to a minimum of 15 percent of income.

Summing Up

The impact of taxation in Newfoundland on the incentive for investment in mineral exploration and mine development is shown to be substantial. In the base case, for example, the expected value of exploration per economic discovery is reduced from a potential value of $22 million to $11 million on an after-tax basis, similarly, the expected net present value associated with mine development decreases from $71 million to $30 million after tax.

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[18]. The small variations in federal tax payments shown in figure 17 from Quebec to British Columbia arise because of differences in the number of discoveries which would be economic (see table 35).

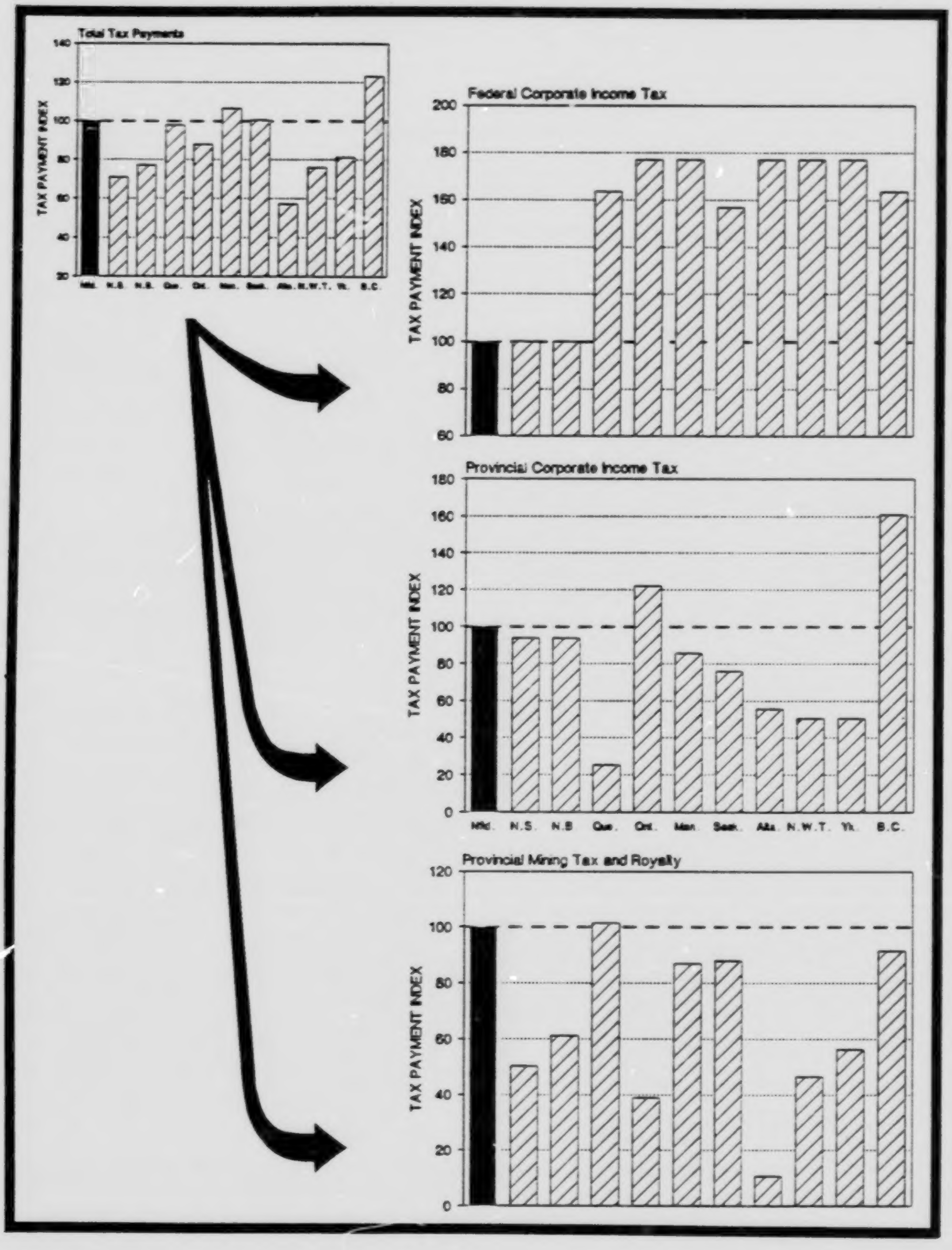

Figure 17. Inter-Provincial Comparison of Tax Payments by Component: Newfoundland's Competitive Standing

The governments' tax share is found to be 48 percent of the actual value realized from mineral exploration and 58 percent of the corresponding figure for mine development.

The after-tax effects of Newfoundland's taxation policies are found to be sensitive to future metal price levels, the degree to which exploration costs can be expensed for tax purposes, and whether the taxation of the development and production phases of mineral supply is on an individual project or an integrated company basis.

The effects of Newfoundland's taxation system tend to be on the onerous side of the spectrum of Canadian inter-provincial assessments presented. The overall incidence of taxation in Newfoundland is shown to be significantly lower than in British Columbia; about the same as in Quebec, Manitoba, and Saskatchewan; and significantly higher than in Nova Scotia, New Brunswick, Ontario, Alberta, the Northwest Territories, and the Yukon Territory. Federal corporate income tax in Newfoundland and the other atlantic provinces is much lower than in the other jurisdictions because of the investment tax credit. On the other hand, the Newfoundland corporate income tax rate is relatively high, and Newfoundland mining tax ranks with the Quebec system as the most burdensome in Canada. This latter finding is mainly attributable to unfavourable depreciation and processing allowance rates.

8. IMPACT OF REGIONAL DEVELOPMENT POLICY OPTIONS

In this chapter, the capability developed to assess the economic potential and after-tax value of base metal and gold mining in Newfoundland is applied to illustrate the comparative effects of several regional development policy options.

The starting point for this evaluation is the study's base case conditions evaluation in chapter 4 on a potential value basis and in chapter 7 on an after-tax basis. We are therefore utilizing the time distributions of average cash flows for an economic deposit shown in figures 7 and 15, and the associated undiscounted cash flow appraisals and expected value measures presented in tables 5-6 and 28-29.

Types of Incentive

For illustrative purposes, we evaluate and compare the economic effects of the following five types of regional development incentive.

1. Geologic Data Base Development
   A government program of this type would consist of geoscience surveys, mapping, and interpretation at regional and reconnaissance levels, not specific to any one particular exploration project. The assumption is made that these government expenditures would relieve mining companies of costs they would otherwise incur at the start of exploration. The exploration period would be effectively shortened from the viewpoint of the mining company and the potential returns from exploration success would, therefore, lie closer to the start of investment.

2. Direct Assistance for Mineral Exploration
   A grant program to reimburse eligible companies for a share of specified types of exploration expenditures they have incurred is envisaged here, along the lines of the OMEP program in Ontario and the FAME program in British Columbia. For evaluation purposes, we assume that this financial assistance would be spread evenly over the exploration period.

3. Support for New Mine Development
   This type of regional development program would provide direct government financial assistance for mine access roads, power, housing, townsite construction, processing facilities, or any other sort of preproduction capital expenditure deemed appropriate. The assumption is made that this government assistance would be spread over the mine development period as a fixed proportion of annual capital expenditures.

4. Mine Production Incentive
   On a before-tax basis, a government program that would subsidize operating costs - power, transportation, or labour expenditures, for example - is envisaged here. After tax, the assistance could be in the form of an income or mining taxation incentive that would reduce mining company tax payments compared to the liabilities otherwise associated with the current Newfoundland tax system. In both cases, we assume for evaluation purposes that the benefits of this type of government incentive would be spread over the production period as a constant proportion of annual operating costs.

5. Assistance at the End of Mine Life
   This type of government program would apply to operating mines faced with closure. The assistance would extend the mine life, thereby allowing more time for exploration success and/or to ease the social and economic consequences of closure on the dependent communities. For evaluating purposes, the assumption is made that the government assistance program would subsidize mine operating costs beyond the closure date which would otherwise apply.

Evaluation Assumptions

For each type of incentive, it is assumed that the cost of the program to government is $10 million per economic deposit.[19] The effective level of assistance provided is maintained at $10 million in both the potential value and after-tax appraisals. This implies that tax credits which mining companies otherwise would receive through the write off of exploration expenditures, development capital, and operating costs are either maintained (incentive types 2-5) or, where the tax credits are foregone (type 1 incentive), compensated for in the level of assistance provided. In all cases considered, the public cost of the incentive program is therefore \$10 million per economic deposit.[20]

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[19]. We have also evaluated the impact of a $5 million level of assistance.

A further assumption, with respect to sourcing the required funds is that government is indifferent to when the assistance is provided in the three-phase mineral supply cycle. In other words, there is no government cost-of-capital consideration with respect to the timing of program expenditures: \$10 million of assistance is provided in all five cases.[21] Within a region of interest, Newfoundland and Labrador in this instance, mineral supply activities at any point in time include a mixture of exploration programs, mine development opportunities, and new and mature operating mines. Realistically, then, there would be immediate demands for government assistance, irrespective of the type of incentive program formulated.

Before-Tax Assessment

Figure 18 utilizes the before-tax time distribution of average cash flows for an economic deposit in Newfoundland (assuming base case conditions) which was assessed in chapter 4 (figure 7). The five \$10-million regional development incentive programs are overlain

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[20]. An alternative way of making the after-tax assessment would be to assume that mining company tax credits would be affected by the government assistance received. In this situation, the net cost of the incentive to government on an after-tax basis would in most cases be considerably less than \$10 million and would vary among the types of program considered.

[21]. We have also evaluated the impact of a 3-percent time value adjustment among the various types of assistance. These results are not presented here because of the preliminary, illustrative nature of the examination.

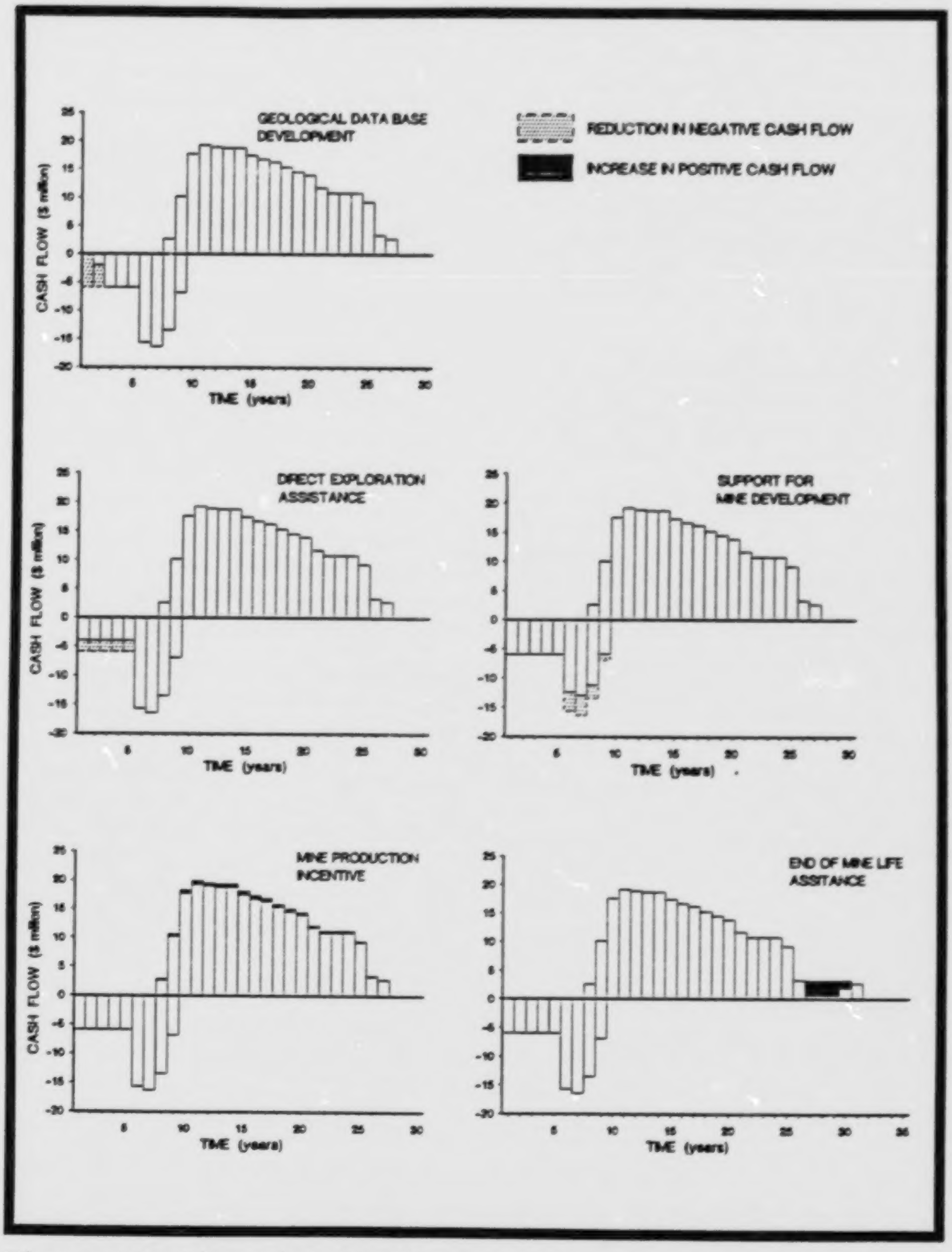

Figure 18. Time Distributions of Average Cash Flows for an Economic Deposit: Before-Tax Impact of Regional Development Incentive Programs on Base Case Conditions

in turn on this base case distribution. The type 1 program reduces the exploration period from the mining company's viewpoint whereas type 5 assistance has the effect of extending the productive mine life. The other three incentive programs (types 2-4) impact within the boundaries of the base case cash flow distribution.

The average cash flow characteristics for an economic deposit are summarized in table 36. Note the effect of the type 1 and type 5 incentives on the exploration and production periods respectively. The average exploration expenditure per economic discovery is reduced from $32 million to $22 million for the geologic data base (type 1) and exploration assistance (type 2) schemes. In the case of infrastructure support for mine development (type 3), the average development capital cost is lowered from $47 million to $37 million. The mine production incentive (type 4) reduces production costs from $213 million to $203 million. Consequently, in these four cases, the average cash flow per economic deposit from the viewpoint of the mining company is enhanced by $10 million, increasing from $175 million in the base case to $185 million after each form of government assistance is provided.

The end-of-mine-life assistance (type 5) is assumed to cover operating costs in the years beyond the closure date which would otherwise apply, in this example, for about another four years. Consequently, the revenue from mine production and the cash flow per economic deposit each would increase by $25 million as indicated in table 36.[22]

The associated expected value assessments are presented in table 37. All five types of regional development incentive program are shown to enhance the expected value per economic discovery (EV) and the expected rate of return relative to the economic potential associated with the base case conditions. The amount of improvement is a function of when the incentive is provided. This is due to the time value considerations incorporated in the expected value criteria.

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[22]. The assumption made here that the government would pay for $10 million of production costs to allow the company to receive an additional $25 million of revenue and cash flow is admittedly unrealistic. If, at the other extreme, the assistance is designed to maintain a breakeven operation, there would be no economic incentive to continue from the mining company's point of view.

Table 36

AVERAGE CASH FLOW CHARACTERISTICS FOR AN ECONOMIC DEPOSIT: BEFORE-TAX IMPACT OF REGIONAL DEVELOPMENT INCENTIVE PROGRAMS ON BASE CASE CONDITIONS

Characteristic	Base Case	Regional Development Incentive Program				
		Type 1	Type 2	Type 3	Type 4	Type 5
Time periods (years):						
Exploration phase	5	3	5	5	5	5
Development phase (maximum)	4	4	4	4	4	4
Production phase (maximum)	20	20	20	20	20	24
Undiscounted values ($ million):						
Revenue	467	467	467	467	467	492
Exploration expenditure	32	22	22	32	32	32
Development capital cost	47	47	47	37	47	47
Production cost	213	213	213	213	203	213
Cash flow	175	185	185	185	185	200

Table 37

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND: BEFORE-TAX IMPACT OF REGIONAL DEVELOPMENT INCENTIVE PROGRAMS ON BASE CASE CONDITIONS

	Average Exploration Expenditure (E,$ mill.)	Average Return (R,$ mill.)	Expected Value (EV,$ mill.)	Rate of Return (%)
Base case	25	47	22	12
Regional development incentive program				
Type 1	17	50	33	15
Type 2	17	47	30	14
Type 3	25	50	25	13
Type 4	25	50	25	12
Type 5	25	50	25	12

Geologic data base development (type 1) is shown to have the greatest impact, increasing EV from $22 million to $33 million, and raising the expected rate of return from 12 to 15 percent. This is the only one of the incentives that lowers the average exploration expenditure (E) and enhances the average return (R). There are two other factors not included in the evaluation that recommend this type of policy option:

- information spillovers. $10 million of geologic data base expenditures can, if efficiently invested, provide direct benefits of a multiple of that amount to a number of mining companies which based their exploration programs on the information provided over a period of time. In other words, provision of geologic data by government at the regional and reconnaissance stages has the potential to raise the efficiency of exploration by reducing duplication of effort among private companies;

- since the assistance is provided broadly for the exploration environment, there is less chance of inefficiency with respect to encouraging uneconomic mining company investment than for the other types of incentive that are more specifically focused on particular exploration projects, development opportunities, and operating mines.

Direct financial assistance for mineral exploration (type 2) is also shown in table 37 to have a significant effect on enhancing the expected value measures. The improvements in before-tax expected values associated with the type 3, 4, and 5 policy options are similar and less significant.

The comparative benefits of the five types of incentive shown in table 37 and outlined above are based on a long-term view of the mineral supply process, considering costs and returns from the start of exploration. As the relevant corporate planning and government policy timeframes become shorter, the comparative benefits of the policy options obviously change. For example, if the concern is economic justification for the development of a new mine (Hope Brook or Duck Pond say), the two types of exploration incentive (shown to provide the greatest long-term benefit) would be of no help.

After-Tax Assessment

The after-tax time distribution of average cash flows for an economic deposit in Newfoundland under base case conditions, taken from figure 15 in chapter 7, is shown in figure 19. Once again, each of the five $10-million regional development policy options are overlain in turn on this distribution. The average cash flow characteristics after the application of each type of incentive are compared with the previously evaluated base case characteristics in table 38. The associated after-tax measures of expected value are provided in table 39.

The after-tax and after-assistance exploration expenditures required per economic discovery are shown to average only about $1 million for the type 1 and 2 policy options. This is because a high level of government assistance to exploration is already being provided through the write off of exploration expenditures for tax purposes before the regional incentives are applied. For the federal and Newfoundland taxation systems, the tax credits realized from exploration write offs total about $21 million per economic discovery, leaving the mining company with an after-tax cost of (32-21) = $11 million as shown for the base case in table 38. When another $10 million of exploration assistance is provided, a balance of only $1 million remains. With the type 1 incentive program, this expenditure would be made at the end of the exploration phase. When the incentive takes the form of direct financial assistance, the $1 million of mining company expenditures would be spread over the five-year average exploration period. While government exploration assistance of this magnitude is unrealistic, and would likely prove to be extremely inefficient, the example serves the purpose of comparing the economic types of incentive at a constant level of government expenditure.

The after-tax mine production incentive (type 4) is assumed to take the form of a mining taxation allowance. Thus, its effect is to reduce tax payments rather than production costs (as was the case before tax) by $10 million, from $104 million to $94 million as shown in table 38.

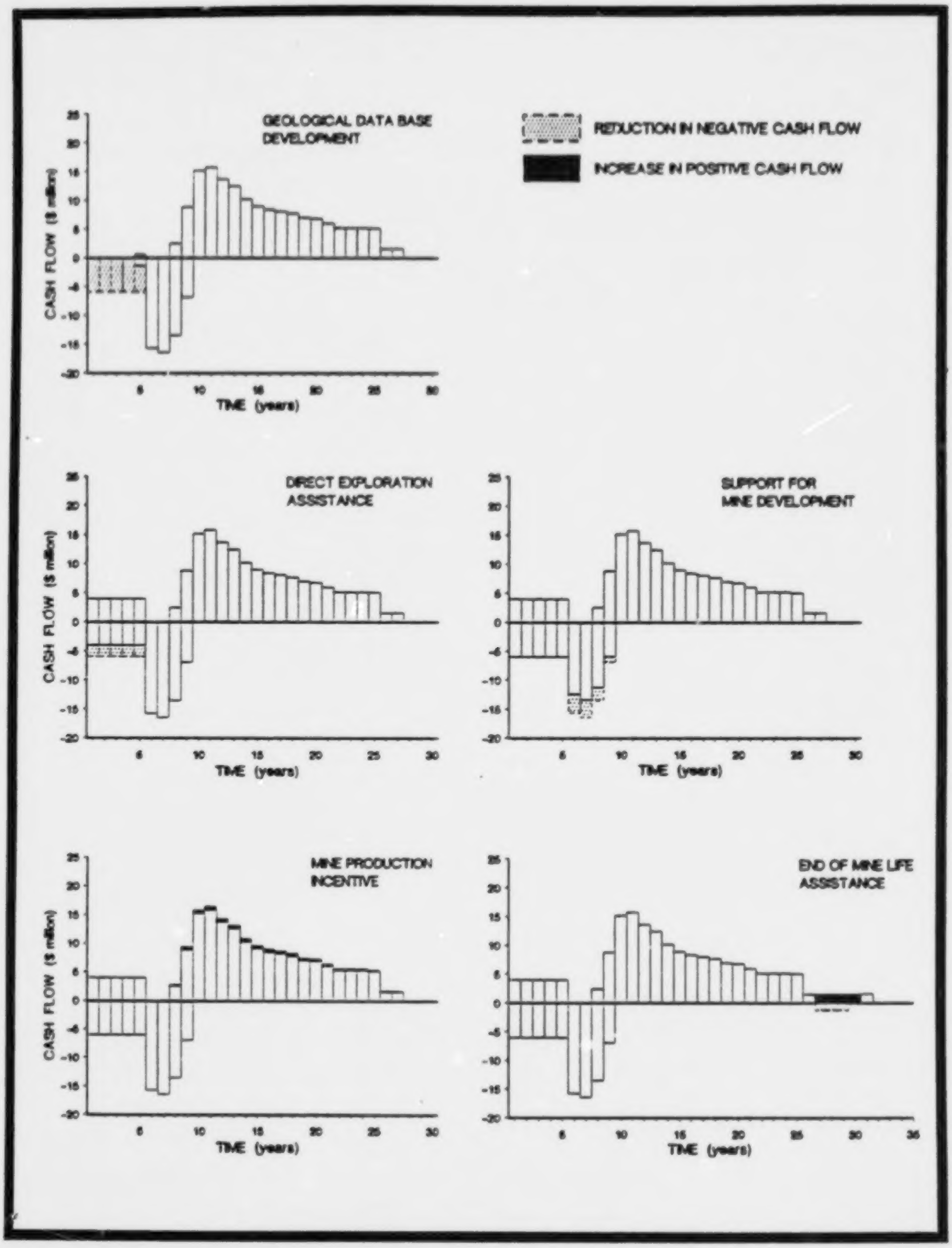

Figure 19. Time Distributions of Average Cash Flows for an Economic Deposit: After Tax Impact of Regional Development Incentive Programs on Base Case Conditions

Table 38

AVERAGE CASH FLOW CHARACTERISTICS FOR AN ECONOMIC DEPOSIT: AFTER-TAX IMPACT OF REGIONAL DEVELOPMENT INCENTIVE PROGRAMS ON BASE CASE CONDITIONS

Characteristic	Base Case	Regional Development Incentive Program				
		Type 1	Type 2	Type 3	Type 4	Type 5
Time periods (years):						
Exploration phase	5	1	5	5	5	5
Development phase (maximum)	4	4	4	4	4	4
Production phase (maximum)	20	20	20	20	20	24
Undiscounted values ($ million):						
Revenue	467	467	467	467	467	492
Exploration expenditure	11	1	1	11	11	11
Development capital cost	47	47	47	37	47	47
Production cost	213	213	213	213	213	213
Tax payments	104	104	104	104	94	101
Cash flow	92	102	102	102	102	110

Table 39

EXPECTED VALUES FOR MINERAL SUPPLY IN NEWFOUNDLAND: AFTER-TAX IMPACT OF REGIONAL DEVELOPMENT INCENTIVE PROGRAMS ON BASE CASE CONDITIONS

	Average Exploration Expenditure (E,$ mill.)	Average Return (R, $ mill.)	Expected Value (EV,$ mill.)	Rate of Return (%)
Base case	9	20	11	12
Regional development incentive program				
Type 1	1	31	30	18
Type 2	1	20	19	17
Type 3	9	26	17	14
Type 4	9	23	14	13
Type 5	9	22	13	12

The comparative expected value results presented in table 39 are ordered in the same way as the before tax assessment (table 37), the impact of the government assistance on investment incentive being greatest for the type 1 program and decreasing systematically to the type 5 program. The differences relative to the base case results are however larger and more distinct than on a before-tax basis. The reason for this is that a fixed $10-million incentive represents a larger proportional improvement on after-tax cash flows ($92 million per economic deposit) than on before-tax cash flows ($175 million per economic deposit).

Summing Up

This chapter illustrates the possible effects of five regional development policy options - geologic data base development, direct financial assistance for exploration, support for new mine development, mine production incentives, and end-of-mine assistance - on the economic potential of base metal and gold supply in Newfoundland. The assessments, made on both before-tax and after-tax bases, are of an exploratory nature.

Results suggest that geologic data base development would have the greatest impact on enhancing economic performance. Information spillover and policy efficiency considerations also recommend this type of regional development option.

The regional policies illustrated here could be directly linked into the study data base and methodology in the same way as the mining taxation policies analyzed in chapter 7. This would enable a full and more detailed range of policy options to be examined in terms of their direct effects on policy efficiency, investment incentive, and government revenues.

9. CONCLUSION

The economic potential of base metal and gold mining in Newfoundland has been assessed and the results analyzed with a view to providing guidelines for public policy formulation.

The economic characteristics appraised provide a factual record of the mineral supply process as it has evolved in Newfoundland since the second world war. Having evaluated this historical experience in terms of current outlook conditions, the results can be applied when looking ahead to estimate both the requirements for and the consequences of government policy.

The assessments of economic potential are intended to illustrate several important and sometimes neglected features of mineral exploration and mine development with particular reference to Newfoundland.

1. Mineral deposits are the focal point of mineral exploration and mine development. Therefore, they are the building blocks we should use for economic analysis of the mineral supply process. For example, the present examination includes the 18 significant base metal and gold deposits discovered in Newfoundland during the 40-year period 1946-85.

2. A composite profile of an economic mineral deposit can be synthesized from the characteristics of all economic deposits. This is illustrated by the assessment made for 10 of the 18 discoveries in Newfoundland which are found to be economic for anticipated future conditions. This type of representative profile is a useful way of summarizing the potential value of mining, and measuring the direct effects of government policy.

3. The mineral supply process is particularly sensitive to future economic conditions and to government policies because of the high degree of variability in potential which exists among individual mineral deposits. For example, an almost 100-times difference is shown in net present value between the lower-decile and upper-decile statistics for the 10 economic base metal and gold deposits evaluated in Newfoundland. Economic variability of this magnitude, a reflection of underlying differences in geological parameters, can best be taken into

account for policy analysis, by examining all significant deposits which have been discovered.

4. The mineral supply process starts with the search for economic deposits. In the long-term, the economic potential of mineral supply has to allow for the exploration activity that is a prerequisite for mine development. This up front activity is portrayed in the study by the $32 million and five years required on average to find and delineate an economic deposit in Newfoundland.

5. While mineral exploration and mine development are integral parts of the mineral supply process, their economic characteristics are quite different and should be clearly distinguished. For anticipated future conditions in Newfoundland, this distinction is illustrated by the $22-million expected value of an economic deposit assessed at the start of exploration as compared to the average value of $71 million appraised at the start of mine development. The $49-million enhancement in potential value which occurs in this case reflects exploration's economic contribution to the mineral supply process.

6. When historical experience is documented and analyzed with a view to providing future planning guidelines, it is important to examine possible time trends. According to the evaluation procedure employed here, time trends measure the interplay of depletion effects, and advances in geological concepts and exploration technology. One of the significant study findings is the marked deterioration in the potential value of base metal supply which has occurred throughout most of Canada during the past 20 years. This disturbing overall result contrasts with the trend in Newfoundland which is shown to have made an encouraging comeback in the most recent decade analyzed (1976-85). Further examination and explanation of these results should be undertaken.

7. Relative measures of economic performance provide useful standards in a competitive world, particularly because their validity is not so dependent on the uncertainties associated

with absolute measurement of mineral supply potential. In the present study, for example, Newfoundland's competitive standing is evaluated by making similar but more general appraisals of economic potential for the appalachian region and for Canada.

8. Assessment of the economic potential of mining provides a basis for evaluating the direct effects of government mineral policies. For this purpose, appropriate policy regimes are imposed on the potential value assessments, and measures of policy efficiency, investment incentive, and government revenue are derived. This type of application is illustrated in the study by analyzing the effects of the current taxation systems operative in Newfoundland and more generally in Canada. The effects and incidence of taxation in Newfoundland are compared with those which characterize ten other Canadian jurisdictions, showing another aspect of competitive position.

9. The capability developed to assess the economic potential of mining in Newfoundland is also used to illustrate the comparative impact of five types of regional development policy. While the assessments are of an exploratory nature, they delineate another possible area of government policy application for the study methodology and data base.

It is costly and ineffective to approach each mineral policy issue on an ad hoc basis. The data base, evaluation procedure, and economic assessments shown in this study for base metal and gold mining in Newfoundland are designed to provide a more efficient and sustainable on-going capability. We suggest that the Newfoundland government consider adopting this type of approach to support mineral policy formulation and decision-making.

Finally, the following recommendations for further work are put forward for consideration:

- extend coverage to other commodities of interest in Newfoundland such as iron ore, selected industrial minerals, and rare metals;

- extend coverage to the appalachian region outside of Canada, i.e. to the United States and Europe (Ireland, Norway, Sweden, and Finland in particular). This would provide a basis for international comparisons of mining potential and government mineral policies;

- directly link regional development policy options into the evaluation software in the same way as the mining taxation policies analyzed, thus allowing examination of their direct effects in terms of policy efficiency, investment incentive, and government revenues;
- transfer the data base and computer software procedures to the Newfoundland Department of Mines, in order to make them operational and available for on-going use;
- develop a related monitoring and projecting system for operating mines, development opportunities, and exploration activities in Newfoundland.

APPENDICES

APPENDIX I

INFLATION MULTIPLIER SERIES USED IN STUDY

The inflation multiplier, derived from the Gross Domestic Product (GDP) Implicit Price Index, is used to convert historical current-dollar statistics to 1987-dollar equivalents.

Year	GDP Implicit Price Index (1981 = 100)	Change From Previous Year (percent)	Inflation Multiplier (1987= 1.000)
1946	17.1		7.620
1947	18.8	9.9	6.931
1948	21.2	12.8	6.146
1949	22.1	4.2	5.896
1950	22.6	2.3	5.765
1951	25.2	11.5	5.171
1952	26.2	4.0	4.973
1953	26.2	0.0	4.973
1954	26.6	1.5	4.898
1955	26.8	0.8	4.862
1956	27.8	3.7	4.687
1957	28.4	2.2	4.588
1958	28.8	1.4	4.524
1959	29.4	2.1	4.432
1960	29.7	1.0	4.387
1961	29.9	0.7	4.358
1962	30.3	1.3	4.300
1963	30.9	2.0	4.217
1964	31.7	2.6	4.110
1965	32.8	3.5	3.973
1966	34.4	4.9	3.788
1967	35.8	4.1	3.640
1968	37.1	3.6	3.512
1969	38.8	4.6	3.358
1970	40.6	4.6	3.209
1971	41.9	3.2	3.110
1972	44.3	5.7	2.941
1973	48.2	8.8	2.703
1974	55.1	14.3	2.365
1975	60.6	10.0	2.150

APPENDIX I (continued)

Year	GDP Implicit Price Index (1981 = 100)	Change From Previous Year (percent)	Inflation Multiplier (1987 = 1.000)
1976	65.8	8.6	1.980
1977	69.9	6.2	1.864
1978	74.2	6.2	1.756
1979	81.6	10.0	1.597
1980	90.2	10.5	1.445
1981	100.0	10.9	1.303
1982	108.7	8.7	1.199
1983	114.1	5.0	1.142
1984	118.0	3.4	1.104
1985	121.7	3.1	1.071
1986	125.3	3.0	1.040
1987	130.3	4.0	1.000

Source:

1947-86: prepared by Karen Wilson, Income and Expenditure Accounts Division, Statistics Canada.

1946: estimated from the relationship with the consumer price index (CPI) for the 1947-51 period as follows -

average (GDP/CPI) for 1947-51 = 0.90;
CPI for 1946 = 19.0;
estimated GDP index for 1946 = 19.0(.90) = 17.1.

1987: preliminary estimate based on January-September.

APPENDIX II

EXPLORATION EXPENDITURE ESTIMATES

Mineral exploration expenditures are based on data collected by Statistics Canada (STCAN, Dominion Bureau of Statistics, DBS, prior to 1969) from mining and exploration companies. These data are grouped by province and territory and, until 1963, by commodity group. After 1963, proportions of the provincial expenditure totals are broken out to represent individual commodities. Exploration expenditures for three commodity groups are pertinent to this study: total metallic minerals; base metals (copper, lead, zinc, molybdenum); and gold. In order to derive these series, it is necessary to first deduct non-metallic exploration expenditures and then non-study metallic mineral expenditures from STCAN provincial totals.

Once the commodity breakdowns by province have been determined they can be grouped into specific exploration environments. For the present study, the appalachian region is of interest.

Metallic Mineral Exploration

Canada

Estimates of non-metal exploration expenditures have been deducted from the overall exploration expenditures described above to obtain a series representing total metallic mineral exploration expenditures for Canada from 1946-85. This series is shown in table 40. These expenditures represent total "cost of prospecting by metal mining companies" as given by DBS for the period 1946-67. From 1968-85, the expenditures reflect STCAN values for both on-property and off-property metallic mineral exploration. For the sake of continuity, figures in some years have been altered to reflect changes in the format and content of the STCAN series over time. Furthermore, the provincial totals for metallic mineral exploration supplied by STCAN are sometimes smaller than corresponding values obtained by summing the commodity breakdowns supplied by other sources. This problem arises particularly in cases where one metal accounts for a large proportion of total metallic expenditures, as was the case for uranium in Saskatchewan in the 1970s and for nickel in Manitoba in the early 1950s. When this situation occurs, the STCAN provincial totals have been adjusted upwards, thus increasing the Canadian total proportionately.

Newfoundland

Total metallic mineral exploration expenditures for Newfoundland are shown in the table 41. Values for the 1949-80 period are based on Newfoundland provincial government estimates of private off-shore exploration expenditures with subjective estimates of expenditures for non-metal exploration deducted. DBS and STCAN values for this time are generally much lower than corresponding NFP estimates. This is due to a combination of the following factors: Newfoundland only joined confederation in 1949, many of the mining companies exploring in Newfoundland in the early years of the study were from the United States, and a large part of exploration was for iron ore which appears to have been generally less well covered by STCAN and DBS than other metals.

From 1981-85, total metallic exploration expenditures reflect estimates by STCAN and EMR. In some years the Newfoundland value is based on a prorated portion of the Atlantic Canada exploration expenditures.

Exploration for Non-Study Metals

In order to derive exploration expenditure series for the commodities examined in this study (gold and base metals), expenditures for non-study metals must be deducted from total metallic mineral exploration expenditures as described above. The non-study metals comprise four commodity groupings: nickel, uranium, iron ore and "others".

Nickel exploration expenditure estimates are based on Inco and Falconbridge nickel exploration expenditures by year and by province over the 1951-85 period, subjective estimates of nickel exploration expenditures by other organizations, and DBS data for nickel-copper mines for 1946-63.

Uranium exploration expenditure estimates for the period 1946-65 are based on a synthesis of published estimates, data obtained from a number of provincial and federal government sources, and subjective estimates of exploration personnel. From 1975-85, estimates reflect published figures from provincial governments in Saskatchewan, and Quebec as well as values obtained through surveys of the uranium industry by URAG.

It is difficult to obtain information on iron ore exploration expenditures in Canada over the study period. Subjective estimates based on provincial and federal government reports form the basis of the iron ore series in the early years of the study. For 1975-85, data is more complete because of better figures from provincial governments and the beginning of detailed commodity breakdowns for exploration expenditures by EMR.

"Other" metals include tin, tungsten, chromite, niobium, platinum group and other less important metals. Exploration expenditures for this category are small in most years and are based on subjective estimates from a combination of provincial and federal government as well as mining company sources.

Gold Exploration

Canada

Deducting the exploration expenditures for non-study metals from those for total metallic minerals leaves the values for gold and base metals. To complete the commodity breakdown, gold exploration expenditures have been separated as shown in table 40.

From 1946-63, only exploration by gold mining companies was classified by DBS as gold exploration and gold mining companies were assumed to have looked only for gold. Other companies were considered not to have explored for gold. While this was not strictly the case, we assume that exploration by gold mining companies for other metals was offset by exploration expenditures of other companies searching for gold.

Estimates for gold exploration from 1964-74 are based on subjective estimates by federal and provincial governments and exploration personnel.

From 1975, the Statistics Canada questionnaire sent to exploration and mining companies asks for breakdowns of exploration expenditures by commodity and province. Estimates of total gold expenditures in each province are based on totals obtained when individual company expenditures for gold are totalled. This is done for the years 1975, 1977, 1979, 1981, 1983, and 1985. Values for years in which disaggregated data are missing during the 1975-85 interval are estimated by interpolating between the values for adjacent years.

Newfoundland

Gold exploration expenditure estimates in Newfoundland for the 1946-85 period are shown in table 41. These estimates are based on the same criteria as described above for Canadian gold exploration. DBS values are used for the 1949-67 period, while subjective estimates cover the 1946-48 and 1968-74 periods. From 1975-85, gold exploration expenditures reflect EMR compilations of STCAN individual company exploration expenditures for gold. Actual figures have been supplied for the years 1975, 1977, 1979, 1981, 1983, and 1985. Values for the remaining years during this period have been estimated by interpolating between values for adjacent years.

Base Metal Exploration

Canada

The process of deducting exploration expenditures for all other metals from the value for total metallic mineral exploration expenditures has left a residual which represents expenditures for base metal exploration. For the purposes of this study, the base metals group comprises copper, lead, zinc and molybdenum. Base metal exploration expenditures for Canada during the 1946-85 period are shown in table 40.

In a few cases, the residual value for a particular province in a particular year was obviously either too high or too low in relation to the overall series. In these instances, the values have been changed on the basis of subjective estimates by government and mining company sources.

For 1985, base metal exploration expenditures have been derived by deducting estimates for nickel exploration from the value for base metal exploration reported by EMR.

Newfoundland

Base metal exploration expenditures for Newfoundland are shown in table 41. These values have been determined using the residual process as described above with the exception of 1985 where the value reflects EMR estimates of the sum of individual companies' base metal exploration expenditures during that year.

Exploration in the Appalachian Region

Canada can be divided into four broad geologic regions or exploration environments. These are the appalachian, shield, cordilleran and other regions. The appalachian region has been isolated here to provide a comparison with the province of Newfoundland and the rest of Canada. Note that the overlap is not complete because Labrador (part of the province of Newfoundland) is in the shield region. However, in practical terms, the vast majority of the province's base metal and gold exploration expenditures and all of the discoveries evaluated occur on the island itself.

Exploration expenditures for gold and base metals in the appalachian region are presented in table 42. The appalachian region comprises the provinces of Nova Scotia and New Brunswick as well as parts of Quebec and Newfoundland. In Quebec, the area south of the St. Lawrence River is considered to be in the appalachian while the remainder of the province falls within the shield region. In Newfoundland, as outlined above, the island of Newfoundland is considered to be within the appalachian region, while Labrador is in the shield region.

Constant Dollar Exploration Expenditures

To examine real constant dollar trends in exploration expenditures, inflationary effects have to be removed from the current dollar series presented in tables 40-42. Since the purchasing power of a dollar is assumed to remain constant, some year (1987 in this case) is specified to define the constant money base. The current dollar expenditures are converted to constant 1987 dollars using the inflation multiplier series derived from the Gross Domestic

Product (GDP) Implicit Price Index for Canada presented in appendix I.

Table 43 shows total metallic, gold, and base metal exploration expenditures in Canada in constant 1987 dollars. Tables 44 and 45 show similar breakdowns for Newfoundland and the appalachian region respectively. These estimates are used for study purposes as summarized in table 1 in the text.

Exploration Expenditure Data Sources

BCP	British Columbia provincial government mining reports.
BMK	Saskatchewan uranium expenditures provided by Bruce McKnight.
CMY	Canadian Minerals Yearbook.
DBS	Dominion Bureau of Statistics (becomes Statistics Canada, STCAN, after 1968).
DC	Federal government data and estimates provided by Donald Cranstone.
DIAND	Department of Indian and Northern Affairs, Ottawa.
EMR	Energy, Mines and Resources Canada.
FALC	Falconbridge Limited.
HBM&S	Hudson Bay Mining and Smelting Limited.
INCO	Inco Limited.
NFP	Newfoundland provincial government data provided by John Fleming and Ken Andrews.
NSP	Nova Scotia provincial government data.
QP	Quebec provincial government data from "Statistiques sur l'investissement de l'industrie minerale du Quebec".
SCORE	Ontario provincial government data from "Ontario Mineral SCORE".
SP	Saskatchewan provincial government data provided by Philip Reeves.
STCAN	Statistics Canada (DBS prior to 1969).
URAG	Uranium Resource Appraisal Group, Energy, Mines and Resources Canada.

TABLE 40

EXPLORATION EXPENDITURES IN CANADA
($ current thousand)

Year	Total Metallic Minerals	Base Metals	Gold	Base Metals and Gold
1946	9,316	1,313	6,420	7,733
1947	7,460	777	4,187	4,964
1948	5,815	1,490	2,501	3,991
1949	7,258	1,777	3,211	4,988
1950	7,678	2,223	2,756	4,979
1951	11,742	2,354	2,414	4,768
1952	18,036	4,013	2,566	6,579
1953	22,063	6,712	2,573	9,285
1954	32,250	10,447	3,400	13,847
1955	34,744	12,741	1,461	14,202
1956	57,608	23,703	4,265	27,968
1957	65,439	29,940	3,372	25,312
1958	45,703	13,486	2,247	15,733
1959	57,124	25,853	3,648	29,501
1960	48,314	25,338	3,815	29,153
1961	47,028	25,997	3,663	29,660
1962	47,323	23,638	4,994	28,632
1963	44,422	22,880	4,706	27,586
1964	50,929	31,625	4,279	35,904
1965	57,467	30,489	4,595	35,084
1966	72,652	43,782	4,971	48,753
1967	75,614	46,404	5,502	51,906
1968	104,113	65,080	8,092	73,172
1969	136,850	85,963	10,829	96,792
1970	152,683	97,906	11,100	109,006
1971	126,537	76,514	9,353	85,867
1972	104,180	67,219	6,812	74,031
1973	118,673	75,784	11,379	87,163
1974	130,073	78,185	13,960	92,145
1975	150,823	80,842	19,773	100,615
1976	169,159	83,412	18,394	101,806
1977	221,011	96,924	26,662	123,586
1978	258,877	86,038	36,631	122,669
1979	324,194	118,173	49,201	167,374
1980	478,273	95,197	104,956	300,153
1981	546,834	119,577	176,581	406,158
1982	416,863	140,290	185,061	325,351
1983	377,179	116,289	198,404	314,693
1984	464,080	131,775	273,494	405,269
1985	496,487	92,636	353,870	446,506

TABLE 41

EXPLORATION EXPENDITURES IN NEWFOUNDLAND
($ current thousand)

Year	Total Metallic Minerals	Base Metals	Gold	Base Metals and Gold
1946	200	97	3	100
1947	200	96	4	100
1948	300	196	4	200
1949	662	454	4	458
1950	1,703	1,228	0	1,228
1951	1,361	303	0	303
1952	2,675	510	125	635
1953	1,351	848	97	945
1954	1,386	747	66	813
1955	2,957	2,569	0	2,569
1956	3,341	2,253	354	2,607
1957	4,827	1,598	121	1,719
1958	10,411	2,218	51	2,269
1959	14,099	2,191	50	2,241
1960	4,429	1,257	28	1,285
1961	3,633	1,520	3	1,528
1962	4,555	1,717	13	1,730
1963	1,634	1,189	85	1,274
1964	2,364	1,966	63	2,029
1965	2,768	1,699	21	1,720
1966	2,949	2,501	28	2,529
1967	3,668	2,990	28	3,019
1968	3,806	2,804	37	2,841
1969	5,140	4,202	51	4,253
1970	5,393	4,301	54	4,355
1971	4,707	3,464	47	3,511
1972	4,679	3,831	47	3,878
1973	6,212	4,695	62	4,757
1974	5,714	3,738	57	3,795
1975	6,707	3,549	67	3,616
1976	5,705	2,110	57	2,167
1977	6,864	2,545	69	2,614
1978	7,920	3,174	79	3,253
1979	11,790	3,174	117	3,291
1980	11,700	5,361	1,197	6,558
1981	14,661	9,531	2,260	11,791
1982	11,474	8,448	1,814	10,262
1983	8,287	6,359	1,367	7,726
1984	11,693	5,615	5,410	11,025
1985	12,861	2,152	9,459	11,611

TABLE 42

EXPLORATION EXPENDITURES IN THE APPALACHIAN REGION
($ current thousand)

Year	Base Metals	Gold	Base Metals and Gold
1946	141	135	276
1947	138	68	207
1948	241	71	312
1949	449	95	544
1950	1,086	64	1,150
1951	447	84	531
1952	714	214	928
1953	3,540	360	3,900
1954	5,412	291	5,703
1955	5,096	148	5,244
1956	6,096	719	6,814
1957	4,072	544	4,616
1958	2,664	285	2,949
1959	4,471	465	4,936
1960	4,365	483	4,849
1961	4,027	142	4,169
1962	3,914	159	4,073
1963	2,867	257	3,124
1964	4,412	159	4,571
1965	3,801	271	4,072
1966	5,081	209	5,290
1967	6,184	247	6,431
1968	6,737	291	7,028
1969	9,609	418	10,027
1970	8,455	334	8,789
1971	7,889	335	8,225
1972	7,856	283	8,139
1973	10,106	446	10,552
1974	9,722	487	10,209
1975	11,169	632	11,802
1976	11,170	391	11,561
1977	13,054	348	13,402
1978	9,868	516	10,384
1979	8,179	785	8,964
1980	18,803	3,983	22,785
1981	28,362	7,973	36,335
1982	20,788	6,703	27,491
1983	18,111	7,394	25,505
1984	20,971	15,681	36,652
1985	9,633	27,368	37,001

TABLE 43

EXPLORATION EXPENDITURES IN CANADA
($ 1987 thousand)

Year	Total Metallic Minerals	Base Metals	Gold	Base Metals and Gold
1946	70,987	10,001	48,920	58,921
1947	51,704	5,384	29,019	34,404
1948	35,740	9,159	15,372	24,531
1949	42,793	10,477	18,932	29,409
1950	44,267	12,819	15,890	28,709
1951	60,714	12,173	12,482	24,655
1952	89,698	19,957	12,761	32,718
1953	109,726	33,381	12,796	46,177
1954	157,977	51,176	16,655	67,831
1955	168,923	61,945	7,103	69,048
1956	270,012	111,096	19,990	131,086
1957	300,236	100,664	15,471	116,134
1958	206,774	61,013	10,166	71,180
1959	253,172	114,580	16,168	130,748
1960	211,963	111,161	16,737	127,898
1961	204,941	113,290	15,963	129,253
1962	203,505	101,653	21,476	123,129
1963	187,320	96,483	19,844	116,327
1964	209,339	129,992	17,588	147,580
1965	228,291	121,119	18,254	139,373
1966	275,191	165,838	18,829	184,667
1967	275,210	168,897	20,025	188,922
1968	365,658	228,568	28,420	256,988
1969	459,576	288,684	36,366	325,050
1970	490,015	314,215	35,624	349,838
1971	393,503	237,944	29,086	267,029
1972	306,426	197,712	20,036	217,749
1973	320,811	204,867	30,761	235,628
1974	307,595	184,892	33,012	217,904
1975	324,294	173,825	42,515	216,340
1976	334,976	165,176	36,425	201,600
1977	411,985	180,676	49,700	230,376
1978	454,605	151,089	64,326	215,415
1979	517,677	188,700	78,565	267,265
1980	690,898	281,975	151,616	433,591
1981	712,525	299,139	230,085	529,224
1982	499,699	168,167	221,835	390,002
1983	430,731	132,800	226,574	359,374
1984	512,451	145,511	302,002	447,513
1985	531,572	99,182	378,876	478,059
1946-55	832,528	226,472	189,930	416,403
1956-65	2,275,553	1,061,050	171,658	1,232,707
1966-75	3,518,279	2,165,440	294,676	2,460,116
1976-85	5,097,121	1,812,415	1,740,004	3,552,419
1946-85	11,723,481	5,265,377	2,396,268	7,661,645

TABLE 44

EXPLORATION EXPENDITURES IN NEWFOUNDLAND
($ 1987 thousand)

Year	Total Metallic Minerals	Base Metals	Gold	Base Metals and Gold
1946	1,524	739	23	762
1947	1,386	665	28	693
1948	1,844	1,205	25	1,229
1949	3,906	2,679	24	2,703
1950	9,818	7,079	0	7,079
1951	7,038	1,565	0	1,565
1952	13,303	2,536	622	3,157
1953	6,717	4,216	482	4,698
1954	6,791	3,660	323	3,983
1955	14,375	12,492	0	12,492
1956	15,658	10,562	1,659	12,221
1957	22,146	7,331	555	7,886
1958	47,104	10,034	231	10,264
1959	62,486	9,712	222	9,934
1960	19,431	5,516	123	5,639
1961	15,833	6,623	35	6,658
1962	19,589	7,383	56	7,439
1963	6,891	5,016	358	5,374
1964	9,716	8,083	259	8,342
1965	10,997	6,749	83	6,833
1966	11,171	9,471	106	9,577
1967	13,352	10,881	106	10,987
1968	13,367	9,849	130	9,979
1969	17,261	14,113	171	14,284
1970	17,307	13,804	173	13,977
1971	14,638	10,771	146	10,917
1972	13,762	11,268	138	11,407
1973	16,792	12,691	168	12,859
1974	13,513	8,841	135	8,975
1975	14,422	7,630	144	7,774
1976	11,297	4,178	113	4,291
1977	12,795	4,745	129	4,873
1978	13,908	5,573	139	5,712
1979	18,826	5,068	187	5,255
1980	16,901	7,745	1,729	9,474
1981	19,103	12,419	2,945	15,364
1982	13,754	10,127	2,174	12,301
1983	9,464	7,262	1,561	8,823
1984	12,912	6,200	5,974	12,174
1985	13,770	2,304	10,127	12,431
1946-55	66,701	36,837	1,526	38,363
1956-65	229,850	77,007	3,581	80,589
1966-75	145,587	109,320	1,417	110,737
1976-85	142,730	65,621	25,078	90,699
1946-85	584,868	288,785	31,602	320,387

TABLE 45

EXPLORATION EXPENDITURES IN THE APPALACHIAN REGION
($ 1987 thousand)

Year	Base Metals	Gold	Base Metals and Gold
1946	1,075	1,207	2,103
1947	959	473	1,432
1948	1,479	438	1,917
1949	2,649	561	3,210
1950	6,263	366	6,629
1951	2,310	434	2,744
1952	3,550	1,065	4,614
1953	17,606	1,790	19,397
1954	26,513	1,424	27,937
1955	24,776	718	25,494
1956	28,571	3,368	31,940
1957	18,683	2,497	21,180
1958	12,055	1,288	13,342
1959	19,815	2,062	21,877
1960	19,152	2,120	21,272
1961	17,547	619	18,166
1962	16,831	684	17,515
1963	12,090	1,085	13,175
1964	18,133	655	18,788
1965	15,101	1,075	16,176
1966	19,246	790	20,036
1967	22,509	899	23,408
1968	23,660	1,023	24,683
1969	32,268	1,405	33,673
1970	27,134	1,071	28,206
1971	24,535	1,043	25,577
1972	23,106	832	23,938
1973	27,319	1,206	28,524
1974	22,991	1,152	24,143
1975	24,016	1,360	25,376
1976	22,119	774	22,893
1977	24,334	650	24,983
1978	17,329	905	18,235
1979	13,061	1,253	14,314
1980	27,162	5,753	32,915
1981	36,956	10,388	47,345
1982	24,919	8,035	32,954
1983	20,683	8,443	29,126
1984	23,157	17,315	40,472
1985	10,313	29,302	39,616
1946-55	87,180	8,297	95,477
1956-65	177,977	15,454	193,431
1966-75	246,782	10,781	257,563
1976-85	220,033	82,819	302,852
1946-85	731,973	117,351	849,324

APPENDIX III

POSSIBLE ECONOMIC DISCOVERIES FOR EVALUATION

Base Metal Deposits: Newfoundland

	Discovery Date				
Name	Pre-1946	1946-55	1956-65	1966-75	1976-85
BETTS COVE	x				
BOUNDARY					x
CLEMENTINE			x		
COLCHESTER	x				
DANIELS HARBOUR			x		
DUCK POND					x
GREAT BURNT LAKE				x	
GULLBRIDGE	x				
LITTLE BAY	x				
LUCKY STRIKE	x				
MACLEAN		x			
MACLEAN EXTENSION					x
MING			x		
OLD BUCHANS	x				
ORIENTAL NO. 1	x				
ORIENTAL NO. 2		x			
PILLEYS ISLAND	x				
POINT LEAMINGTON				x	
RAMBLER EAST			x		
RAMBLER MAIN	x				
ROTHERMERE		x			
SKIDDER				x	
TILT COVE	x				
TULKS EAST					x
TULKS HILL			x		
WHALESBACK			x		
YORK HARBOUR	x				

Base Metal Deposits: Other Appalachian Region

	Discovery Date				
Name	Pre-1946	1946-55	1956-65	1966-75	1976-85
Nova Scotia					
GAYS RIVER				x	
JUBILEE				x	
SALMON RIVER			x		
STIRLING	x				
WALTON			x		
New Brunswick					
BRUNSWICK 6		x			
BRUNSWICK 12		x			
CAPTAIN			x		
CARIBOU		x			
CLEARWATER			x		
FLAT LANDING BROOK				x	
HALFMILE LAKE		x			
KEY ANACON		x			
LITTLE RIVER		x			
MURRAY BROOK BASE METAL		x			
NIGADOO		x			
PABINEAU RIVER				x	
STRATMAT			x		
THIRD PORTAGE LAKE			x		
WEDGE			x		
Quebec					
CAPELTON	x				
CLINTON COPPER			x		
CUPRA			x		
EUSTIS	x				
GASPE Cu MOUNTAIN	x				
GASPE E					x
HARVEY HILL	x				
HUNTINGTON		x			
LINGWICK				x	
MADELAINE				x	
NEEDLE MOUNTAIN	x				
SOLBEC			x		
SUFFIELD	x				
WEEDON	x				

Base Metal Deposits: Other Canada

	Discovery Date				
Name	Pre-1946	1946-55	1956-65	1966-75	1976-85
Quebec					
ABCOURT		x			
ALDERMAC	x				
AMOS	x				
AMULET A	x				
AMULET C	x				
AMULET F	x				
ANGLO AMERICAN			x		
ANSIL					x
BARVALLEE			x		
BARVUE		x			
BATEMAN BAY			x		
BELFORT		x			
BELL ALLARD			x		
CAMPBELL MAIN	x				
CEDAR BAY	x				
CONIAGAS		x			
COOKE				x	
COPPER CLIFF		x			
COPPER RAND		x			
COPPER RAND 3		x			
CORBET			x		
CORNER BAY					x
DELBRIDGE			x		
DEVLIN					x
DUNRAINE	x				
EAST SULLIVAN	x				
EAST WAITE		x			
ESTRADES					x
FIGUREY				x	
GARON LAKE			x		
GOLDEN MANITOU	x				
GRANDROY		x			
GRASSET LAKE				x	
GREVET					x
HENDERSON			x		
HORNE	x				
ICON			x		
ISLE DIEU					x
JACULET		x			
JOLIET	x				
JOUTEL			x		
KELLY DESMOND			x		
KOKKO CREEK		x			
LACORNE	x				
LEMOINE				x	

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date				
	Pre-1946	1946-55	1956-65	1966-75	1976-85
Quebec (continued)					
LESSARD				x	
LOUVEM				x	
LOUVEM ZINC				x	
MAGUSI				x	
MATTAGAMI			x		
MERRILL ISLAND	x				
MILLENBACH				x	
MOBRUN		x			
NEW CALUMET	x				
NEW HOSCO			x		
NEW INSCO				x	
NORBEC			x		
NORITA			x		
NORITA EAST					x
NORMETAL	x				
OLD WAITE	x				
ORCHAN			x		
PERRY		x			
POIRIER			x		
PORTAGE			x		
PREISSAC	x				
QUEBEC MANITOU			x		
QUEMONT	x				
RIBAGO DEEP					x
ROBITAILLE			x		
SCOTT					x
SELBAIE A1				x	
SELBAIE A2				x	
SELBAIE B				x	
SPRINGER	x				
TACHE LAKE		x			
VAUZE			x		
VENDOME		x			
WAITE DUFAULT	x				
WEST MACDONALD	x				
Ontario					
BERENS RIVER	x				
BIG NAMA CREEK			x		
BI-ORE	x				
BRISMIL			x		
BRUCE	x				

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date				
	Pre-1946	1946-55	1956-65	1966-75	1976-85
Ontario (continued)					
CHANCE					x
COLDSTREAM		x			
COPPER CORP		x			
COPPER LODE A			x		
COPPER LODE E			x		
CROWNBRIDGE			x		
DIXIE					x
ERRINGTON	x				
F GROUP				x	
GECO		x			
GENEVA LAKE	x				
GOULAIS RIVER				x	
GRASSY PORTAGE			x		
HEADVUE		x			
JAMELAND				x	
JAMIESON			x		
KAM KOTIA	x				
KENDON		x			
KIDD CREEK			x		
KINGDON	x				
KRISTINA	x				
LYON LAKE					
MATTABI				x	
MAYBRUN		x			
MUNRO COPPER		x			
ONAMAN LAKE				x	
PATER		x			
RYAN LAKE		x			
SCHUMACHER COPPER			x		
SHUNSBY		x			
SOUTH BAY				x	
STRALAK	x				
STURGEON				x	
TEMAGAMI		x			
TRIBAG			x		
UPPER BEAVER	x				
VERMILLION	x				
WILLECHO		x			
WILLROY		x			
WINSTON LAKE					
ZENMAC	x				

Base Metal Deposits: Other Canada (continued)

	Discovery Date				
Name	Pre-1946	1946-55	1956-65	1966-75	1976-85
Manitoba					
ANDERSON LAKE			x		
BOB	x				
CENTENNIAL				x	
CHISEL LAKE			x		
COPPERMAN	x				
CUPRUS	x				
DICKSTONE	x				
FAREWELL LAKE				x	
FLIN FLON	x				
FL-DH		x			
FOX			x		
FRANCES LAKE					x
GHOST LAKE			x		
HYERS ISLAND	x				
JUNGLE			x		
LOST LAKE				x	
MACBRIDE LAKE				x	
MORGAN LAKE					x
NORTH STAR		x			
OSBORNE LAKE		x			
PINEBAY			x		
RAIL LAKE				x	
REED LAKE				x	
ROD				x	
RUTTAN				x	
SCHIST LAKE		x			
SHERRIDAN	x				
SPRUCE POINT				x	
STALL			x		
SYLVIA					x
TROUT LAKE MANITOBA					x
VAMP LAKE	x				
WESTARM				x	
WHITE LAKE			x		
WIM				x	
Saskatchewan					
BIGSTONE LAKE					x
BIRCH LAKE		x			
CALLINAN					x
CORONATION		x			
FLEXAR		x			
GEORGE LAKE				x	
MCKENZIE			x		
RAMSEY				x	
WADEN BAY		x			

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date				
	Pre-1946	1946-55	1956-65	1966-75	1976-85
British Columbia					
ADANAC				x	
AFTON				x	
ANNEX				x	
ASHBY	x				
BELL			x		
BENSON				x	
BERG			x		
BETHLEHEM		x			
BIG BONANZA				x	
BIG BULL AND TULSEQUAH CHIEF	x				
BLUEBELL		x			
BONANZA	x				
BOSS MOUNTAIN			x		
BRENDA				x	
BRITANNIA	x				
BLUE GROUSE		x			
CARIBOO BELL			x		
CATFACE			x		
CHUCHUA CREEK					x
CIRQUE					x
CLACIER GULCH			x		
COPPER MOUNTAIN	x				
CRAIGMONT			x		
DANKOE	x				
DAVIS KEAYS				x	
EAGLEHEAD			x		
ENDAKO			x		
GALORE CREEK			x		
GIBRALTER				x	
GOLDSTREAM				x	
GRANDUC		x			
GRANISLE			x		
HARPER CREEK				x	
HB		x			
HIDDEN CREEK	x				
HIGHMONT			x		
HUCKLEBERRY			x		
HW					x
INDIAN CHIEF	x				
INGERBELLE				x	
ISLAND COPPER				x	
J & L	x				
JA				x	
JERSEY		x			

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date Pre-1946	1946-55	1956-65	1966-75	1976-85
British Columbia (continued)					
KING FISSURE			x		
KITSAULT			x		
KUTCHO CREEK				x	
LARA					x
LORNEX			x		
LUCKY JIM	x				
LYNX			x		
MAGGIE				x	
MAGNUM			x		
MIDWAY					x
MINERAL KING		x			
MONARCH	x				
MORRISON			x		
MOTHER LODE AND SUNSET	x				
MYRA FALLS				x	
OK				x	
ORO DENORO	x				
OWEN LAKE	x				
PHOENIX	x				
PRICE					x
PROSPERITY	x				
RED CHRIS				x	
RED MOUNTAIN			x		
REEVES	x				
ROBB LAKE				x	
RUTH VERMONT	x				
SAM GOOSLY				x	
SAMATOSUM					x
SCHAFT CREEK				x	
SCOTIA			x		
SENECA			x		
SILVER GIANT	x				
SILVER STANDARD	x				
SINMAX CREEK	x				
SNOWSHOE	x				
SOUTH CIRQUE					x
SPOKANE				x	
SULLIVAN	x				
SUNRO			x		
SUNSHINE				x	
SUSTUT				x	
TASU	x				
TROJAN	x				
TROUT LAKE BC				x	
TWIN J	x				
VALLEY COPPER				x	
WINDY CRAGGY			x		
YALE MINE	x				

Base Metal Deposits: Other Canada (continued)

	Discovery Date				
Name	Pre-1946	1946-55	1956-65	1966-75	1976-85
Northwest Territories					
AGRICOLA				x	
BEAR TWIT				x	
CONWEST 408				x	
CORONET				x	
DEB					x
DIANNE				x	
ECLIPSE			x		
GAYNA				x	
GONDOR					x
GREAT SLAVE REEF 1					x
GREAT SLAVE REEF 2					x
HACKETT A				x	
HACKETT BOOT				x	
HACKETT CLEAVER				x	
HEK					x
HENINGA				x	
HIGH LAKE			x		
HOOD 10				x	
HOOD 41				x	
HOOD 41A					x
HOOD 462					x
HOWARDS PASS				x	
INDIAN MOUNTAIN		x			
IZOK				x	
JAY				x	
JUNE				x	
MUSK					x
NANISIVIK			x		
PINE POINT 1		x			
PINE POINT 2			x		
PINE POINT 3				x	
PINE POINT 4					x
PINE POINT 5					x
POLARIS				x	
PRAIRIE CREEK				x	
PYRAMID			x		
REDSTONE			x		
TURNBACK	x				
WRECK				x	

Base Metal Deposits: Other Canada (continued)

	Discovery Date				
Name	Pre-1946	1946-55	1956-65	1966-75	1976-85
Yukon Territory					
ANNIV				x	
ARCTIC CHIEF	x				
BARB			x		
BELLEKENO DEEP					x
BEST CHANCE			x		
BIRMINGHAM	x				
CASH				x	
CASINO				x	
COWLEY PARK			x		
DY					x
ELSA	x				
FARO			x		
GALKENO	x				
GEM				x	
GOZ				x	
GRUM				x	
HART				x	
HECTOR-CALUMET	x				
HUNDERE			x		
HUSKY				x	
HUSKY SOUTHWEST					x
JASON					x
KEEWENAW		x			
KENO	x				
LITTLE CHIEF			x		
LOGAN				x	
LUCKY QUEEN	x				
MEL				x	
MINTO				x	
NADALEEN					x
NO CASH	x				
QUARTZ LAKE		x			
SADIE LADUE	x				
SILVER KING	x				
SWIM			x		
TINTA HILL	x				
TINTINA				x	
TOM		x			
VANGORDA		x			
VENUS	x				
VERA					x
WAR EAGLE	x				
WILLIAMS CREEK				x	

Gold Deposits: Newfoundland

Name	Discovery Date 1946-1955	1956-65	1966-75	1976-85
CAPE RAY				x
HOPE BROOK				x

Gold Deposits: Other Appalachian Region

Name	Discovery Date			
	1946-1955	1956-65	1966-75	1976-85
Nova Scotia				
BEAVER DAM				x
COCHRANE HILL			x	
FOREST HILL				x
New Brunswick				
CAPE SPENCER				x
MURRAY BROOK GOLD				x

Gold Deposits: Other Canada

	Discovery Date			
Name	1946-1955	1956-65	1966-75	1976-85
Quebec				
ASTORIA				x
AUGMITTO				x
BACHELOR LAKE	x			
BEACON				x
BOUSQUET				x
BOUZAN	x			
CALLAHAN				x
CAMFLO		x		
CHADBOURNE				x
CHIBEX (MESTON)	x			
CHIMO		x		
CONS.CENTRAL CADILLAC			x	
DEKA				x
D'ESTOR			x	
DOYON			x	
DUMAGAMI		x		
DUMONT			x	
EAGLE-TELBEL		x		
EASTMAIN				x
ELDRICH	x			
ELLISON				x
FERDERBER				x
GOLDEN POND				x
GOLDEX		x		
GWILLAM			x	
HEVA				x
KIENA		x		
KIERANS				x
LAC SHORTT		x		
MALARTIC HYGRADE		x		
MARBAN		x		
MONTAUBAN				x
MONTAUBAN SOUTH				x
NEW PASCALIS				x
NORBEAU				x
NORLARTIC				x
NORTH PASCALIS				x

Gold Deposits: Other Canada (continued)

	Discovery Date			
Name	1946-1955	1956-65	1966-75	1976-85
Quebec (continued)				
ORENADA 4				x
OTISH MOUNTAIN				x
REMNOR WEST				x
SILIDOR				x
SLEEPING GIANT				x
S-3		x		
Ontario				
ANNCO		x		
AQUARIUS				x
BELL CREEK				x
BROULAN REEF	x			
CAMERON LAKE				x
CARSHAW				x
CLAVOS				x
DETOUR LAKE			x	
DONA LAKE				x
FAVOURABLE LAKE		x		
GOLDEN PATRICIA				x
GOLDEN ROSE				x
HEMLO				x
H.G. YOUNG	x			
HIGHLAND CROW				x
HOYLE POND				x
HUGH PAM	x			
KREMZAR				x
MAGINO				x
MAGNACON				x
MATHESON EAST				x
MCBEAN				x
MCDERMOTT				x
MISSANABIE	x			
NIGHTHAWK LAKE				x
OPAPAMISKAN				x
OROFINO				x
OWL CREEK			x	
ROBIN RED LAKE		x		
ROMFIELD				x
SCADDING				x
SHOAL LAKE			x	
ST. ANDREWS		x		
SURLUGA		x		
TISDALE				x
WILMAR		x		

Gold Deposits: Other Canada (continued)

	Discovery Date			
Name	1946-1955	1956-65	1966-75	1976-85
Manitoba				
BULLMOOSE (TERRA)				x
FARLEY LAKE				x
MACLELLAN (AGASSIZ)		x		
PUFFY LAKE				x
SHERRGOLD				x
SQUALL LAKE	x			
TARTAN LAKE				x
Saskatchewan				
KOMIS (WADDY)				x
MAHOGANY (JOLU)				x
RIO (FLIN FLON)			x	
SEABEE	x			
STAR LAKE				x
TOWER LAKE EAST				x
WEDGE LAKE				x
WEEDY LAKE				x
British Columbia				
AYLWIN				x
BAKER			x	
BIG MISSOURI				x
BLACKDOME				x
CARIBOU				x
CAROLIN			x	
CINOLA			x	
ERICKSON				x
GOLDEN BEAR				x
LAWYERS				x
MASCOT (NICKEL PLATE)				x
REG				x
RICHFIELD				x
SILBAK				x
SULPHERETS				x
TILLICUM				x
TOODOGGONE (ENERGEX)				x

Gold Deposits: Other Canada (continued)

Name	Discovery Date			
	1946-1955	1956-65	1966-75	1976-85
Northwest Territories				
COLOMAC				x
CORONATION GULF		x		
COURAGEOUS LAKE				x
CULLATON LAKE		x		
INDIN LAKE				x
LOLOR		x		
LUPIN		x		
REN				x
SALMITA			x	
SUPERCREST	x			
TUNDRA	x			
Yukon Territory				
BROWN MCDADE	x			
KETZA				x
MOUNT NANSEN		x		
MOUNT SKUKUM				x

APPENDIX IV

OTHER DISCOVERIES CONSIDERED BUT EXCLUDED FROM THE EVALUATION

Base Metal Deposits: Newfoundland

Name	Discovery Date	Reason for Exclusion
BIG RAMBLER POND	1969	Too Small
BUCHANS WEST	*	Too Small
HAND CAMP	1928	Too Small
LA MANCHE	1855	Too Small
LADY POND	Pre-1900	Too Small
LAKE BOND	1952	Too Small
LOCKPORT	1870	Too Small
MCNEILY	Pre-1900	Too Small
MILES COVE	1898	Too Small
MUD POND	1937	Too Small
ROUND POND	1937	Too Small
SOUTH POND	1950	Too Small
TERRA NOVA	1862	Too Small

* discovery date unknown

Base Metal Deposits: Other Appalachian Region

Name	Discovery Date	Reason for Exclusion
Nova Scotia		
COXHEATH	Pre-1900	Too Small
DEEP COVE	1964	Too Low Quality
LIME HILL	1968	Too Small
LOCHABER LAKE	1970	Too Low Quality
MEAT COVE	1953	Too Low Quality
SMITHFIELD	Pre-1900	Too Low Quality
New Brunswick		
PORTAGE LAKE	*	Too Small
ANNIDALE	1900	Too Small
ARMSTRONG A&B	1956	Insufficient Information
BENJAMIN RIVER	1895	Too Low Grade
BERESFORD	1952	Too Small
DORCHESTER	1870	Too Low Grade
DRUMMOND IRON	1952	Insufficient Information
EVANDALE	1967	Insufficient Information
KEYMET MINE	1946	Too Small
LEGACY	1970	Too Low Quality
MCMASTER	*	Insufficient Information
NEPISIQUIT	1956	Insufficient Information
NICHOLAS DENYS 1	1965	Too Low Quality
NINE MILE BROOK	1975	Too Small
ORVAN BROOK	1945	Too Small
ROCKY TURN	1956	Insufficient Information
TAYLOR BROOK	1977	Too Low Grade
TEAHAN	Pre-1900	Too Small
Quebec		
ARSENAULT LAKE	1973	Insufficient Information
ASCOT	*	Too Low Quality
BASKET RIVER	1968	Too Small
CANDEGO	1946	Too Small
FEDERAL	1916	Too Small
IVES MINE	1865	Too Low Quality
MID-PATAPEDIA	1968	Insufficient Information
MT. ST. SEBASTIAN	1956	Too Low Quality
PEKAN BROOK	1965	Too Low Quality
PANET METALS	1953	Too Low Quality
PORTNEUF MINERALS	1954	Insufficient Information
UPTON	1847	Too Low Quality

* discovery date unknown

Base Metal Deposits: Other Canada

Name	Discovery Date	Reason for Exclusion
Other Quebec		
ABITIBI COPPER	1952	Too Low Quality
ALLARD RIVER	1946	Too Low Quality
BEAUCHASTEL (DESPINA)	1926	Too Small
BEAUDRY	Pre-1938	Too Small
BELL CHANNEL	1961	Too Small
BROMPTON	1965	Too Low Quality
BRUNEAU MINE	1962	Too Small
CANRAY	1976	Too Low Quality
CERTAC (LAC CERE)	1953	Too Low Quality
CHIB COPPER	1957	Too Small
CRYSLER NO. 2	1952	Too Low Quality
DIK DIK	1951	Too Small
DON ROUYN	1925	Too Low Grade
DUMONT BOURLAMAQUE	1969	Too Small
DUVAN	1954	Too Small
D-68	1952	Too Small
EMPIRE LE TAC	1952	Too Low Quality
FRANELLE	1976	Insufficient Information
FREDERICKSON LAKE	1942	Insufficient Information
HALIWELL	1929	Too Small
HEIGHT OF LAND	1906	Too Small
HEMATITE BAY	1908	Too Low Quality
HUNTER MINE	1955	Too Small
JIMMICK LAKE	1960	Too Small
JOSEPH CLAIMS	1968	Too Small
JOSSELIN	1968	Too Small
KIRKHAM	1952	Too Low Quality
KOKE	1961	Too Low Grade
LAC MOLEAN	1962	Too Small
LAFONTAINE	1945	Too Small
LEITCH	1967	Too Small
LETAC	1952	Insufficient Information
LYNDHURST	1951	Too Small
MILLER COPPER	1956	Too Low Quality
MILLSTREAM	1968	Too Small
MOLY HILL	1939	Too Low Quality
MONPAS	1956	Too Small
MOSS MINE	1916	Too Small
NEPTON BAY	1951	Too Low Quality
NEW BIDLAMAQUE	1938	Insufficient Information
ORENADA	1923	Too Low Quality
PERCH RIVER	1967	Too Small
PRUDHOMME 1	1964	Too Low Quality

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
Other Quebec (continued)		
QUEBEC CHIBOUGAMAU GOLD FIELDS	1951	Too Low Quality
RIBOURDE-SASSURE	1970	Insufficient Information
RICHMOND GULF	1948	Too Low Quality
RIO ALGOM CHIBOUGAMAU	1976	Insufficient Information
SOUCY	1954	Too Low Quality
SOUTH DUFAULT	1947	Too Low Quality
SOUTH RUSTY HILL	1956	Too Low Quality
TRINITY	1947	Too Small
VALRAY (CRANGOLD)	1931	Too Small
WRIGHT MINE	1875	Too Small
Ontario		
ABBICAN	1956	Too Small
ALEXANDER	1975	Too Small
AMORADA DEPOSIT	1958	Too Small
BAR-FIN	1906	Too Small
BIG NAMA	1959	Too Small
BILTON OPTION	1956	Too Small
BOYEA LAKE	1952	Too Small
BRIAR COURT	1918	Too Low Quality
BURROWS LAKE	1918	Too Small
CAMPBELL DUKES	Pre-1949	Too Small
CHENEY MINE	1916	Too Small
CHISOLM	1904	Too Small
CLYDE FORKS	1950	Too Small
COPPER PRINCE	1929	Too Small
DANE	1911	Too Small
DELHI PACIFIC	1907	Too Small
DESTORADA	1951	Too Small
DIADEM	1952	Too Low Quality
DUKES, A.V.	1938	Too Small
ELDORADO	1900	Too Small
ELLA LAKE	1952	Too Small
ENTERPRISE	1870	Too Small
ETHEL COPPER	1952	Too Small
EVANS	1907	Too Small
FRONTENAC LEAD	1866	Insufficient Information
GOUDREAU	1921	Too Small
GRAND PORTAGE	Pre-1900	Insufficient Information
HALLAM	1967	Too Small
HANNAM CLAIMS	1953	Too Low Quality
HIGHLAKE-EVENLODE	1937	Too Low Quality
HERMINA	1910	Too Low Quality

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
Ontario (continued)		
HOLLANDIA	1903	Too Small
HORSCROFT	1852	Too Small
HUNT, CORNELIUS	1915	Too Small
HUNT MINE	Pre-1912	Too Small
INTERPROVINCIAL	1928	Too Small
JARDUN	1951	Too Small
JEFFERSON (STACKPOOL)	1908	Too Small
JURY	1906	Too Small
LONG LAKE MINE	1970	Too Small
MAMAINSE	1882	Too Small
MARICONA	1955	Too Low Quality
MASSEY	1905	Too Small
MATARROW	1948	Too Small
MIRONSKY	1963	Too Low Quality
MORDEY	1964	Too Small
OGEMA	1890	Too Small
PATTERSON	1827	Too Small
PENN COBALT	1905	Too Small
PIDGEON MOLY	1946	Too Low Quality
PLAYTER	1942	Too Small
POTTERDOAL	1926	Too Small
PRACE	1973	Too Small
PURDEX (A-D)	1952	Too Small
QUEBEC	1846	Too Small
REGENTRY METALS	1940	Too Small
RENPRIOR (RENFREW ZN)	1922	Too Small
RICHARDS	1952	Too Small
ROCK LAKE	1898	Too Small
ROSS, C.G.	1914	Too Small
SABINE	1981	Insufficient Information
SATELLITE	1916	Too Small
SETTING NET LAKE	1969	Too Low Quality
SHEBA	1960s	Too Small
SIMON	1961	Too Low Quality
SPAIN	1912	Too Small
STEINBERG	1919	Too Small
SUNSET	1916	Too Small
THUNDER BAY	1927	Too Small
TRETHWAY-OSSIAN	1929	Too Small
TROUT BAY	1958	Too Small
TWIN LAKES	1956	Too Small
VANGUARD	1949	Too Small
WILCOX	1893	Too Small
ZINC LAKE	1912	Too Small

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
Manitoba		
BARRINGTON LAKE	1970	Too Small
GOODENOUGH	1952	Too Small
MANDY	*	Too Small
NORRIS LAKE	1980	Too Low Quality
POT LAKE	1956	Too Small
WEST FRANCES	1976	Too Low Quality
Z DEPOSIT	1947	Too Small
Saskatchewan		
ELIZABETH LAKE	1970	Too Low Quality
MOKOMAN (KNIFE LAKE)	1971	Too Low Quality
PITCHING LAKE	1956	Too Small
SCHOTTS LAKE	1953	Too Low Quality
HANSEN LAKE	1957	Too Low Quality
British Columbia		
ABBOTT	1894	Too Small
AJAX	1965	Too Low Quality
ALKOKELEX	*	Insufficient Information
ALVIJA	1908	Too Small
ANN (GNAWED MTN.)	1969	Too Low Quality
ANNEX	1966	Too Small
AXE	1969	Too Low Quality
BAM (ARCTIC LAKE)	1967	Too Small
BC AND ZINZ CLAIMS	1967	Too Small
BELL MOLY	1966	Too Low Quality
BEND	1967	Too Low Quality
BEVERLY	1951	Too Low Quality
BIG LEDGE	1947	Too Low Quality
BIG ONION	1972	Too Low Quality
BULL RIVER	1968	Insufficient Information
BUZZER	1966	Too Low Grade
CADILLAC	1956	Insufficient Information
CAFB	1959	Too Low Quality
CANAM	1935	Too Low Quality
CARMI & LAKE	1970	Too Low Quality
CATHERINE	1903	Too Small
CLEARWATER	1987	Too Recent
COLBY	*	Insufficient Information
COLLOSSUS	1966	Too Small
COMMERCE	1970	Too Small

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* discovery date unknown

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
British Columbia (continued)		
COPPER CANYON	1960	Too Low Quality
COPPER CROWN	Pre-1920	Too Small
COPPER ROAD	1963	Too Small
COTTON BELT	1925	Insufficient Information
CRONIN	1948	Too Small
CROWN POINT	1928	Too Small
CROY	1970	Too Small
DIVIDE COPPER	1957	Too Low Quality
DOLLY VARDEN	1972	Too Small
DOROTHY	1971	Too Low Grade
DOUBLE ED	1935	Too Low Quality
DRIFTPILE	1979	Too Low Quality
DUNCAN	1961	Too Remote
ECSTALL	1901	Too Low Quality
EDEN	1954	Too Small
EMERALD GLACIER	1950	Too Small
EVENING STAR	1900	Too Low Quality
FISH LAKE	1961	Too Low Quality
FRISCO	1912	Too Low Quality
FX (KINGFISHER)	1960	Too Low Quality
GALLOWAY (PAY)	1963	Too Small
GAMBIER·ISLAND	1967	Too Low Quality
GATAGA	*	Insufficient Informaton
GEORGE COPPER	1927	Insufficient Information
GIANT	1965	Too Low Quality
GOLDEN QUEEN	Pre-1900	Too Small
GREYHOUND	Pre-1916	Too Small
GUNN (HD)	1967	Too Low Quality
HASKIN MTN SE	1969	Insufficient Information
HASKIN MTN WEST	1969	Too Low Grade
HAWK CREEK	1942	Too Small
HI HO	1971	Too Low Quality
HOWE COPPER	1966	Too Low Quality
JACK POT	1902	Too Low Quality
JB	1965	Too Low Quality
JERICHO	1959	Too Low Quality
JOE (IRON CAP)	1956	Too Small
JUBILEE MOUNTAIN	*	Insufficient Information
KAREN (TRAPPER)	1972	Too Low Quality
KELLY CREEK	1965	Too Low Quality
KLISUM	1970	Too Low Quality
KOOTENAY KING	1928	Too Small
KRAIN	1955	Too Low Quality

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* discovery date unknown

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
British Columbia (continued)		
KWANKIA	1967	Too Low Grade
LEEMAC	1971	Too Low Quality
LILY	1900	Too Small
LORNA	1900	Too Low Quality
LORRAINE	1970	Too Low Quality
LUCKY FOUR	1918	Too Small
LUCKY SHIP	1965	Too Low Quality
LUSTDUST	1954	Too Small
MAMIE	1963	Too Small
MAPLE BAY	1923	Too Small
MASTADON ZINC	1949	Too Small
MCDAME-BELL	1964	Too Small
MCVICAR	1925	Too Small
MER	1965	Too Low Quality
MINEX	1968	Too Low Quality
MISTY	1973	Too Low Quality
MOLLY GIBSON	1906	Too Small
MOSQUITO KING	1965	Too Small
MT OGDEN	1967	Too Low Grade
NANIKA (DW)	1968	Too Low Quality
NORTHWEST	1973	Too Small
OWL (COPPER QUEEN)	1928	Too Low Quality
OX LAKE	1968	Too Low Quality
PARADISE	1900	Too Small
PARAMOUNT MINING	1970	Too Low Quality
PAYNE	1891	Too Small
PEN (YUBET)	1965	Too Small
POISON MOUNTAIN	1966	Too Low Quality
POMEROY	Pre-1920	Too Small
POPLAR	1975	Too Low Quality
PORCUPINE	1964	Too Small
PRIMER	1966	Too Low Quality
PYTHON	1900	Too Low Quality
RAINBOW	1896	Too Low Quality
RED WING	1966	Too Small
REGAL Ag (SNOWFLAKE)	1930	Too Small
REY	1973	Too Low Quality
RIVER JORDAN	*	Insufficient Information
ROCKLAND	1899	Too Low Quality
RONDAH	1972	Too Low Quality
ROUNDY CREEK	1968	Too Low Quality
RUDDOCK CREEK	1962	Too Low Quality
SAWMILL	1979	Insufficient Information

* discovery date unknown

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
British Columbia (continued)		
SERB CREEK	1966	Too Low Quality
SILVER BASIN	1969	Too Small
SILVER CHIEF	1915	Too Small
SILVER KING	1965	Too Small
SILVER QUEEN	1955	Too Low Quality
SPAR 1	1949	Too Small
STEAMBOAT	*	Insufficient Information
STEMWINDER	*	Too Small
STORIE	1965	Too Low Quality
ST. EUGENE	*	Insufficient Information
SUMMERS CREEK	1972	Insufficient Information
SUNNY CAVE	1923	Too Small
SUNSHINE CREEK	1966	Too Low Quality
SUSAP (KING EDWARD)	1903	Too Low Quality
TEDDY GLACIER	1963	Too Small
TEDI	1973	Too Small
THOMLINSON MTN	1965	Too Low Quality
TOD RIVER	1967	Too Low Quality
TORIC	1924	Too Small
TORO	1966	Too Small
TROJAN	1957	Too Low Quality
TRUE FISSURE	1900	Too Small
USEBELL	1960	Too Small
VANGUARD	1926	Too Small
VICTOR	1952	Too Small
VIMY 100	1900	Too Low Quality
VULCAN	*	Insufficient Information
WAGNER	1949	Too Small
WARHORSE (BOY SCOUT)	1949	Too Small
WHEAL	1964	Too Low Quality
WHIT	1965	Too Low Quality
WIGWAM	1924	Too Low Quality
WIT, WAG	1964	Too Small
WIZ 21 & 30	1965	Too Low Quality
WOLF	1915	Too Small
YREKA MINE	1954	Too Small
ZIP	1968	Too Small
ZYMOETZ	1966	Insufficient Information

* discovery date unknown

Base Metal Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
Northwest Territories		
CARL 7	1968	Too Small
CORONATION	1969	Too Small
CW GROUP	1957	Too Small
DICK NO. 1	1952	Too Small
HOMER	1945	Insufficient Information
MARINER	1968	Too Small
NOREX MINE	1967	Too Small
O'CONNOR LAKE	1948	Too Small
PR	*	Too Small
RAM AND ROD	1973	Insufficient Information
ROY	1981	Too Small
SOUTH BURNT CREEK	*	Too Small
SPIDER	1949	Too Small
SUSU LAKE	1966	Too Small
VENUS	1972	Too Small
WRIGLEY	1974	Too Low Quality
Yukon Territory		
BLACK CUB	1970	Too Small
CLARK	1973	Too Small
CLEAR LAKE (SUE)	1978	Too Low Quality
EAGLE	1970	Too Small
FORMO	1930	Too Small
GROUNDHOG (Ag CREEK)	1969	Insufficient Information
HORN	1970	Too Low Quality
KETZAKEY (KEY AND STUMP)	1947	Too Remote
KODIAC CUB	1970	Too Small
LOGJAM CREEK	1977	Too Low Quality
LOOKOUT	1918	Insufficient Information
MARK GROUP	1966	Insufficient Information
PESCO-REX	1962	Too Small
PIKE LAKE	1967	Too Low Quality
SHANGHAI	1966	Too Small
TUF	1960	Too Small
VAL	1978	Too Low Quality
WIND R (AHEARNE)	1970	Too Small

* discovery date unknown

Gold Deposits: Other Appalachian Region and Other Canada

Name	Discovery Date	Reason for Exclusion
Nova Scotia		
FIFTEEN MILE STREAM	1985	Too Small
New Brunswick		
ELMTREE	1985	Too Small
Quebec		
BROSNAN	1980	Insufficient Information
CANRAY	1976	Insufficient Information
COSEGO	1982	Insufficient Information
COURVAN	Pre-1975	Too Small
DALEMBERT	1982	Insufficient Information
DARIUS	1974	Mined Previously
DESJARDINS TWP	1955	Too Small
DOUAY TWP	Post-1974	Insufficient Information
DOVERCLIFF	1979	Insufficient Information
FABRIEN	1982	Insufficient Information
FLORIDAN	Post-1974	Too Small
GARNEY	1961	Insufficient Information
GOLD SEARCH	1980	Insufficient Information
GOLDSTACK	1981	Insufficient Information
HOSCO	1982	Old Discovery
JOUBI	1973	Too Small
KEN-CHIB	1955	Insufficient Information
LAC MONTIGNY	Post-1974	Insufficient Information
LYNDHURST	1951	Too Small
MALARTIC	1982	Too Low Grade
MALARTIC HYGRADE NEW	1986	1986 Discovery
MALARTIC HYGRADE #8	1985	Too Small
MONIQUE	1983	Insufficient Information
OKENADA	1974	Insufficient Information
PANDORA	1980	Insufficient Information
QUESABE	1947	Too Small
RAND MALARTIC	1985	Too Small
REMNOR	1980	Mined Previously
SOISSAN	1981	Insufficient Information
VAL ST. GILLIS	1979	Too Small
VALIANT	1964	Too Small
VAUGUELIN	1964	Too Small
VINRAY	1946	Too Small
WESTERN QUEBEC	1979	Insufficient Information
WRIGHTBAR	1986	1986 Discovery

Gold Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
Ontario		
ABINO	1975	Insufficient Information
BEGGS LAKE	1959	Too Small
BOSTON TWP	1980	Too Small
CAMRECO	1980	Insufficient Information
CANREOS	1946	Insufficient Information
EGO	1961	Insufficient Information
GARRISON	Pre-1970	Too Small
KLOTZ LAKE	1983	Insufficient Information
LOUANNA	1946	Too Small
MATTAWASAGA	1984	Insufficient Information
NORSTAR	1958	Too Small
OROSTAR	1974	Too Small
ORPIT	1973	Insufficient Information
RESERVE LAKE	1960	Too Small
SAPAWE	1960	Too Small
SHINING TREE	1984	Insufficient Information
SNOPPY LAKE	1986	1986 Discovery
Manitoba		
JEEP	1947	Too Small
NOKOMIS LAKE	1960	Too Small
NORRIS LAKE	1946	Too Small
VAMP LAKE	1964	Insufficient Information
WADEK BAY	1952	Base Metals
British Columbia		
CAPOOSE LAKE	1979	Too Low Grade
CITY OF PARIS (LEXINGTON)	1968	Insufficient Information
COPCO	1959	Too Small
CUSAC	1985	Too Small
DOME MOUNTAIN	1986	1986 Discovery
DUSTY MAC	1968	Too Small
FRASER GOLD	1983	Insufficient Information
FRENCH	1950	Too Small
IMPERIAL	Post-1974	Too Small
KENVILLE	1946	Too Small
LACANA	1985	Insufficient Information
MOSQUITO CREEK	1973	Too Small
NEW PRIVATEER	1983	Too Small
NUTTLUDE	1979	Too Low Grade
SHE-SHAS	1983	Insufficient Information
SMITH NASH	1960	Insufficient Information
TAURUS	1979	Too Small

Gold Deposits: Other Canada (continued)

Name	Discovery Date	Reason for Exclusion
Northwest Territories		
ARSENO	1946	Too Small
CAMLAREN	1974	Too Small
CASS ZONE	1986	1986 Discovery
RED CLAIM	1985	Too Small
SHEAR LAKE	1983	Too Low Quality
VOL	1962	Too Small
Yukon Territory		
ARCTIC GOLD	1965	Too Small
VENUS MINE	1966	Too Small

APPENDIX V

GENERAL REVENUE AND COST RELATIONSHIPS

Smelter Return Conditions

General Formula

$$NSV = \left[\frac{(M-D)(P-r)}{100}\right] - \left[T + t(P-P_{ev}) + C\right]$$

where:

NSV = net smelter value per tonne of concentrate at the smelter;
M = grade of concentrate, %;
D = unit deduction, %;
P = metal price, \$/tonne;
r = refining charge, \$/tonne of metal;
T = treatment charge, \$/tonne of concentrate;
t = treatment charge price adjustment;
P_{ev} = expected value metal price, \$/tonne;
C = credit for other metals contained, \$/tonne of concentrate.

Notes: penalties are neglected; all concentrate values are expressed on a dry tonne basis.

Copper Concentrate

Unit deduction (D): function of M

M	D
up to 30%	1.0
30%-40%	1.2
over 40%	1.4

t = 0.0
r = 315
T = 115

Credits (C):

Au - pay for 98% above 1 gram per tonne in concentrate
Ag - pay for 98% above 30 grams per tonne in concentrate

$$NSV = \left[\frac{(M-D)(P-315)}{100}\right] - 115 + C^*$$

$$^* C_{au} = (M_{au}-1)(.98\ P_{au})$$

$$C_{ag} = (M_{ag}-30)(.98\ P_{ag})$$

Lead Concentrate

Unit Deduction (D): the greater of .05(M) or 3

r = 130
T = 165
t = .075

Credits (C):

Au - pay for 96% above 1 gram per tonne in concentrate
Ag - pay for 96% above 45 grams per tonne in concentrate

$$NSV = \left[\frac{(M-D)(P-130)}{100}\right] - \left[165 + .075(P-P_{ev})\right] + C^*$$

$$^* C_{au} = (M_{au}-1)(.96\ P_{au})$$

$$C_{ag} = (M_{ag}-45)(.96\ P_{ag})$$

Zinc Concentrate

Unit Deduction (D): the greater of .15(M) or 8

$r = 0.0$
$T = 275$
$t = 0.10$

Credits (C):

Ag - pay for 80% above 50 grams per tonne in concentrate
Cd - pay for 65% above .15% in concentrate

$$NSV = \left[\frac{(M-D)(P)}{100}\right] - \left[275 + .10(P-P_{ev})\right] + C^{*}$$

$$^{*}\ C_{ag} = (M_{ag}-50)(.8\ P_{ag})$$

$$C_{cd} = (M_{cd}-.15)(.65\ P_{cd})/100$$

Concentrate Transportation Costs

Road: 4.3 cents per tonne-km in provinces
8.6 cents per tonne-km in territories
17.2 cents per tonne-km in shield region of Northwest Territories

Rail: up to 500 km, 5.0 cents per tonne-km
500-1500 km, 3.0 cents per tonne-km
over 1500 km, 2.5 cents per tonne-km
14.4 cents per tonne-km in territories

Ocean: Eastern Canada-Europe, $36 per tonne concentrate
Eastern Canada-Japan, $80 per tonne concentrate
Western Canada-Japan, $50 per tonne concentrate
Western Canada-Europe, $58 per tonne concentrate
Within Eastern or Western Canada, $22 per tonne concentrate

Transfer: $5 per tonne concentrate at each transfer point
no. of transfer points = (no. of modes + 1)

Gold Marketing Charges

1. Free Milling Gold Ores
   - assume impure bullion (doré) produced;
   - charge $0.48 per gram ($15 per ounce) of gold content for transportation, refining, and marketing;
   - pay for 98 percent of silver byproduct content.

2. Refractory Gold Ores
   - assume gold concentrate produced;
   - charge $1.29 per gram ($40 per ounce) of gold content for transportation, refining, and marketing;
   - pay for 96 percent of silver byproduct content.

General Deposit Costing Relationships

The generalized deposit costing relationships used in the appraisal when actual data are not available have been developed by T.A. O'Hara. The costing functions provide an order-of-magnitude (±30 percent) level of accuracy. These relationships are outlined as follows:

- mine and mill ore capacity for open pit and underground mines as a function of recoverable ore reserves;
- site preparation cost for open pit mining as a function of topography and tree growth;
- preproduction waste stripping cost as a function of the amounts of soil and waste rock overburden to be removed;
- capital cost of open pit equipment as a function of the annual tonnage of ore and waste to be removed, optimum shovel size, optimum truck size, and drilling conditions;
- capital cost of open pit repair and maintenance facilities as a function of the annual tonnage of ore and waste to be removed;
- capital cost of shaft sinking as a function of rock conditions, mine capacity, and shaft depth;

- capital cost of hoisting plant as a function of mine capacity and hoisting distance;
- capital cost of mine compressor plant as a function of mine capacity;
- underground mine development capital cost as a function of mine capacity and average stope width;
- capital cost of underground mining equipment, maintenance facilities, and sustaining capital requirement as functions of mine capacity and average stope width;
- capital cost of mineral processing plant as a function of ore capacity, topography, tree growth, temperature conditions, hardness of ore, and ore type. Estimated by component: site clearing and mass excavation, concrete foundations and detailed excavation, primary crusher, coarse ore storage, conveying and fine crushing plant concentrator building, fine ore storage and grinding, and the processing section;
- capital cost of electric power supply as a function of mine capacity, mine location and remoteness;
- capital cost of tailings storage as a function of mine capacity, topography, site accessibility, and environmental requirements;
- capital cost of water supply as a function of mine capacity;
- working capital requirement expressed in number of months of operating cost as a function of remoteness;
- number of persons employed as a function of mining method, mine and mill capacities, and employee accommodation provided;
- typical milling recoveries, concentrate grades, and flow of metals among concentrate products, as functions of ore types;
- capital cost of mine access road as a function of topography and distance;
- capital cost of houses, permanent bunkhouse facilities, and townsite amenities as functions of the percentages of employed persons to be accommodated, and remoteness;
- capital cost of general plant services as a function of number of employees;
- project overhead costs as a function of direct project costs;
- operating labour costs for mining, milling, maintenance, and services as a function of mine and mill capacities, mine and mill methods, stope width, and employee accommodation requirements;

- operating materials costs for mining, milling, maintenance, and services as a function of mine and mill capacities, mine and mill methods, stope width, and remoteness;
- electric power operating cost as a function of capacity, location and remoteness.

These order-of-magnitude costing relationships are indexed for variations in construction and mining wage rates among the provinces and territories, and the labour and materials costs can be indexed where appropriate to allow for remoteness cost premiums.

APPENDIX VI

INCOME AND MINING TAXATION SYSTEMS

Taxation Systems in Newfoundland

Federal Corporate Income Tax

Cash Flow Format:

Revenue
- Operating Cost
- Capital Cost Allowance @ 30% db (optional)
- Interest Payments

If negative: Carried Loss (for year X+1 or X-1)

Revenue
- Operating Cost

Net Income before Allowances
- Capital Cost Allowance

Resource Profits
- Resource Allowance
- Interest Payments
- Exploration Expenditures
- Development Expenditures

Income for Earned Depletion
- Earned Depletion Allowance
- Carried Loss (from X-1 or X+1)

Income for Federal Corporate Income Tax
Federal Corporate Income Tax Otherwise Payable
- Investment Tax Credit

Net Federal Corporate Income Tax Payable

Capital Cost Allowance: applied to mine plant and machinery, the mill facility, infrastructure capital, and mine development capital after the start of commercial production. The amount allowable must be reduced by the investment tax credit (see below).

For capital expended during the development stage and for expansions of at least 25% in capacity, the deduction permitted is the greater of 15% of the allowable capital cost in the year of expenditure and 30% per year thereafter on a declining balance basis, or an amount equal to (revenue - operating cost - interest payments) from the new mine, i.e. at 100% against new mine income.

ASSUME - taxation on an individual project basis will use the 100% rate. Taxation on an integrated company basis will use the 15% and 30% rates until new mine income begins and then the balance will be deducted at the 100% rate. Note that while capital cost allowance reduces the amount of resource profits and resource allowance, a carried loss does not. Therefore, using the 15% and 30% rates until new mine income begins may be advantageous even on the individual project basis.

For other capital costs (apart from major expansion) and sustaining capital costs, the capital cost allowance is 15% of the capital cost in the year of expenditure and 30% per year thereafter on a declining balance basis for all except mine development capital costs which are allowable at 100%.

Capital expenditures incurred to control air and water pollution can be deducted at 50% per year on a straight-line basis.

Resource Allowance: 25% of resource profits.

Development Expenditures: mine development capital costs incurred before the start of commercial production are allowed to be deducted at 100%.

Earned Depletion Allowance: $1 for every $3 of allowable capital costs and expenditures up to a maximum of 25% of income for earned depletion in any year.

Allowable capital costs and expenditures include exploration expenditures; mine development, mine plant and machinery, mill facility, and infrastructure capital in the development stage; mine plant and machinery, and mill facility capital associated with a major expansion; and the processing machinery equipment component in other capital costs (other than major expansions) and sustaining capital costs. The amount allowable must be reduced by the investment tax credit (see below).

Carried Loss: losses may be carried back three years and ahead seven years.

Federal Corporate Income Tax: 33% of income for federal tax, plus 3% surtax. Effective tax rate = 33 + 3 (.33) = 33.99%.

Investment Tax Credit: applies to mine plant and machinery, mill facility and infrastructure capital. The investment tax credit is deducted from the federal corporate income tax which would otherwise be payable to determine the net tax payable. The maximum deduction in any year is the federal corporate income tax otherwise payable.*

The rate of tax credit is 20% for applicable investment in the Atlantic Provinces and the Gaspé region of Quebec.

Newfoundland Corporate Income Tax

Income for Newfoundland corporate income tax is derived in exactly the same way as income for federal corporate income tax. The applicable tax rate is 16 percent.

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* As a temporary measure for the period May, 1983 - December, 1988, 20% of any investment tax credits earned in excess of the federal tax otherwise payable is returnable as a cash refund.

Newfoundland Mining Tax*

Cash Flow Format:

Revenue
- Operating Cost

Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

Income for Processing Allowance
- Processing Allowance

Income for Newfoundland Mining Tax
Newfoundland Mining Tax

Depreciation Allowance: all pre-production capital costs allowable on a straight line basis over estimated mine life. Capital expended during the productive life of a mine is allowable at 10 percent on a straight-line basis.

Processing Allowance: 8% per year of the original cost of processing assets but not to be more than 65% of the income for processing allowance.

Newfoundland Mining Tax: 20% on first 20% of income for Newfoundland mining tax; 15% on remaining income for Newfoundland mining tax.

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* Several mining companies have special royalty agreements with the Newfoundland government which override the general mining taxation policies outined here. For example, the operations of the Iron Ore Company of Canada are governed by the Labrador Mining and Exploration Act of 1938 as amended. The method by which the province derives revenue from Wabush Mines' iron ore operation is determined by the Nalco-Javelin Mineral Lands Act as amended.
Base metal and gold deposits discovered on the Anglo-Newfoundland Development (AND) charter lands in the Buchans area, presently controlled by the Selco Division of BP Resources, are subject to the provisions of the Manufacture of Pulp and Paper Act of 1905 as amended. A royalty of 5 percent of taxable income is in this case payable. Depreciation allowance is 10 percent of capital costs per year on a straight-line basis. There is no processing allowance.
The application of such special arrangements is not considered in the present study.

Provincial and Territorial Corporate Income Taxation Elsewhere in Canada

Quebec

Cash Flow Format:

Revenue
- Operating Cost
- Capital Cost Allowance @ 30% db (optional)
- Interest Payments

if negative: Carried Loss (for year X+1 or X-1)

Revenue
- Operating Cost

Net Income before Allowances
- Capital Cost Allowance
- Resource Profits
- Resource Allowance
- Interest Payments
- Exploration Expenditures
- Development Expenditures

same format as for Federal Corporate Income Tax

Income for Earned Depletion
- Earned Depletion Allowance
- Carried Loss (from X-1 or X+1)

Income for Quebec Corporate Income Tax
Quebec Corporate Income Tax

Capital Cost Allowance
Resource Allowance
Development Expenditures

Same rules as for Federal Corporate Income Tax

Carried Loss

Earned Depletion Allowance: same rules as for federal corporate income tax except maximum annual deduction is 33 1/3% of income for earned depletion.

Quebec Corporate Income Tax: 5.5% of Income for Quebec income tax.

Ontario

Cash Flow Format:

Revenue
- Operating Cost
- Capital Cost Allowance @ 30% db (optional)
- Interest Payments

if negative: carried loss (for year x+1 or x-1)

same format as for Federal Corporate Income Tax

Revenue
- Operating Cost

Net Income before Allowances
- Capital Cost Allowance
- Interest Payments
- Exploration Expenditures
- Development Expenditures

Income for Percentage Depletion
- Percentage Depletion Allowance
- Carried Loss (from year X-1 or X+1)

Income for Ontario Corporate Income Tax
Ontario Corporate Income Tax

Capital Cost Allowance
Development Expenditures
Carried Loss

Same rules as for Federal Corporate Income Tax

Percentage Depletion Allowance: 33 1/3% of income for percentage depletion.

Ontario Corporate Income Tax: 14.5% of income for Ontario income tax.

Other Provinces and Territories

In British Columbia, resource allowance is not an allowable deduction in calculating income for B.C. corporate income tax. Otherwise, income for provincial and territorial corporate income tax is derived in exactly the same way as income for federal corporate income tax.

The applicable tax rates are as follows:

Alberta	11%
British Columbia	14%
Manitoba	17%
New Brunswick	15%
Northwest Territories	10%
Nova Scotia	15%
Saskatchewan	17%
Yukon Territory	10%

Provincial and Territorial Mining Taxation Elsewhere in Canada

Nova Scotia

Cash Flow Format:

Gross Metal Revenue
- Smelting, Refining, and Transportation Charges

Revenue = Net Smelter Return

Revenue
- Operating Cost

Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

Income for Processing Allowance
- Processing Allowance

Income for Nova Scotia Mining Tax
Nova Scotia Mining Tax

Depreciation Allowance: all capital costs except post-production mine access capital costs allowable at 100% against new mine income during the first three years of operation and at 30% per year on a straight-line basis thereafter. Post-production mine development capital costs allowable at 100%.

Processing Allowance: 8% per year of the original cost of processing assets but not to be less than 15% nor more than 65% of the income for processing allowance.

Nova Scotia Mining Tax: the greater of 2% of net smelter return or 15% of income for Nova Scotia mining tax (but subject to change by order-in-council).

New Brunswick

Cash Flow Format:

Revenue
- Operating Cost
- Exploration Allowance
- Royalty
- Depreciation Allowance
- Interest Allowance

Income for Processing Allowance
- Processing Allowance

Income for New Brunswick Mining Tax
New Brunswick Mining Tax
- Research Credit

New Brunswick Mining Tax After Credit

Exploration Allowance: $1.50 for every $1 of exploration expenditures.

Royalty: 2% of 'net mill return' starting in the third year of mine operation.

Gross Metal Revenue
- Smelting, Refining, and Transportation Charges

Revenue
- Mill Operating Costs

Return for Processing Allowance
- Processing Allowance

Net Mill Return (i.e., value of the mill feed)

The processing allowance is determined as specified below but the amount deductible in any year cannot exceed 25% of the 'return for processing allowance'.

Depreciation Allowance: includes all capital expenditures except for exploration, research and working capital.

For capital expended during the preproduction development stage and for expansions of at least 25% in capacity, the deduction permitted is up to 100% of the allowable capital cost but not to be less than 5% per year.

Sustaining and other capital costs during the productive life of a mine are allowable at up to 33 1/3% per year on a straight-line basis with no minimum deduction.

New Brunswick (continued)

Assume maximum possible allowance is taken in each case.

Interest Allowance: 8% per year of the undepreciated cost of all assets qualifying for depreciation allowance. Note that it may in some cases be advantageous to depreciate more slowly than possible to take fuller advantage of this allowance.

Processing Allowance: annual rate applied to the original cost of processing assets but not to be less than 15 percent nor more than 65 percent of income for processing allowance.
8% of concentrator assets
15% of smelting and refining assets

New Brunswick Milling Tax:

income for mining tax	marginal rate
up to 100,000	exempt
100,000 and over	16%

Research Credit: 25% of research expenditures.

Quebec

Cash Flow Format:

Revenue
- Operating Cost

if negative: Carried Loss

Revenue
- Operating Cost
- Depreciation Allowance
- Exploration Expenditures

Income for Exploration and Investment Allowance
- Exploration and Investment Allowance

Income for Processing Allowance
- Processing Allowance

Income for Quebec Mining Tax
Quebec Mining Tax Otherwise Payable
- Carried Credit for Unused Exemption
- Deduction for Carried Loss

Net Quebec Mining Tax Payable
Refundable Credit

Depreciation Allowance: mine development capital costs at 100% per year; all other capital costs at 30% per year on a straight-line basis.

Exploration and Investment Allowance: $1 for every $3 of pre-production exploration expenditures, capital costs of processing facilities, and exploration costs incurred at operating underground mines*, up to a maximum or 33 1/3% of income for exploration and investment allowance in any year.

Processing Allowance: annual rate applied to the original cost of processing assets but not to be less than 15% nor more than 65% of income for processing allowance.
8% if ore concentrated
15% if concentrate is smelted and/or refined in Quebec

Rate applies to all processing assets up to and including final stage.

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* Actually limited to a prescribed list of exploration expenditures which are a function of such factors as depth of exploration and distance from mine workings.

Quebec (continued)

The 15% rate applies to gold mill assets if the facility includes a smelter which produces dore or impure bullion.

Quebec Mining Tax Otherwise Payable:

income for mining tax	marginal rate
up to 500,000	exempt
500,000 and over	18%

At the 18 percent tax rate, the $500,000 exemption is equivalent to a credit of $90,000. Any part of the credit which is not used during a given year may be carried forward three years.

Deduction for Carried Loss: 18% of 'carried loss' in the year following the loss. This deduction can be carried back three years and ahead seven years.

Refundable Credit: 18 percent of the loss resulting from exploration expenditures and depreciation allowance during a given year, up to the limit of 18 percent of the loss incurred during the year.

Revenue
- Operating Cost
- Depreciation Allowance
- Exploration Expenditures

if negative; Loss Incurred During Year

Ontario

Cash Flow Format:

  Revenue
- Operating Cost

  Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

  Income for Processing Allowance
- Processing Allowance

  Income for Ontario Mining Tax
  Ontario Mining Tax

Depreciation Allowance: mine development capital costs at 100% per year; mine plant and equipment at 30% per year on a straight-line basis; mill, infrastructure and all other capital assets at 15% per year on a straight-line basis.

Processing Allowance: annual rate applied to the original cost of processing assets but not to be less than 15% nor more than 65% of income for processing allowance.

8% if ore concentrated
12% if ore smelted in Canada
16% if ore refined in Canada
20% if ore refined or fabricated in northern Ontario

Rate applies to all processing assets up to and including final stage.

The 12% rate applies to gold mill assets if the facility includes a smelter which produces dore or impure bullion.

Three-Year Tax Exempt Period: a new mine is exempt from Ontario mining tax for a period of three years from the start of production.

Ontario Mining Tax:

income for mining tax	marginal rate
up to 500,000	exempt
500,000 and over	20%

Manitoba

Cash Flow Format:

Revenue
- Operating Cost

Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

Income for Processing Allowance
- Processing Allowance

Income for Manitoba Mining Tax
Manitoba Mining Tax Otherwise Payable
- Investment Tax Credit

Net Manitoba Mining Tax Payable

Depreciation Allowance: all capital costs at 20% per year on a declining-balance basis. The amount allowable must be reduced by the investment tax credit (see below).

Processing Allowance: average of 8% per year of the original cost of processing assets* but not to be less than 15% nor more than 65% of income for processing allowance.

Manitoba Mining Tax: 18% of income for Manitoba mining tax.

Investment Tax Credit: 5 percent of capital expenditures on mine development, mine plant and machinery, and processing assets, which have been made for the purposes of bringing a new mine into production, carrying out a major expansion, or 'modernizing' existing facilities to increase production potential.

Allowable capital costs for 'depreciation allowances' must be reduced by the amount of the investment tax credit.

The investment tax credit may be deducted in the year a qualified asset is acquired and can be carried forward for another five years.

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* The May 1979 Manitoba budget increased the processing allowance rate from 8 percent to 10 percent per year but restricted the definition of processing assets to exclude common service facilities. Thus, assume 8 percent as an average rate on all processing assets.

Saskatchewan (metallic minerals excluding uranium)

Cash Flow Format:

  Revenue
- Operating Cost

  Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

  Income for Processing Allowance
- Processing Allowance

Income for Saskatchewan Mining Tax
Saskatchewan Mining Tax

Depreciation Allowance: mine development expenditures and mine plant and machinery capital costs allowable at 100%. Capital costs of processing, housing, and townsite facilities allowable at 30% per year on a declining-balance basis. For capital expenditures for road and power facilities, assume half is written off at 100%, and the other half at 30% per year declining balance. Assume 70% of infrastructure capital expenditures is deducted at 30% per year declining balance, and the remaining 30% of the infrastructure at 100%.

Processing Allowance: 8% per year of the original cost of processing assets but not to be less than 20% nor more than 65% of the income for processing allowance for copper-zinc deposits, and not to be less than 15% or more than 65% of income for other deposits.

Saskatchewan Mining Tax: 12.5% of income for Saskatchewan mining tax.

Alberta (metallic minerals)

Payout: date on which the cumulative gross revenue of the mine equals the sum of cumulative allowed capital costs, cumulative operating costs, cumulative on-site exploration and development costs, cumulative annual capital allowance, and cumulative pre-payout royalty.

Allowed Capital Costs: includes all capital expenditures directly attributable to the mine except for exploration expenditures, development costs, and working capital. Included in this category is an allowance for indirect capital costs of 1% of the capital costs incurred.

Operating Costs: includes smelting, refining, and transportation charges, and all other operating costs directly attributable to the mine.

Annual Capital Allowance: 15% of the unrecovered allowed capital costs in a year. Where the period to which the allowance applies is less than a full year, the allowance must be reduced to reflect the eligible period of the year.

Cash Flow Format: applies before payout is achieved, and defines mine mouth revenue after payout occurs.

Gross Revenue
- Smelting, Refining and Transportation Charges
- Mill Operating Costs
- Annual Capital Allowance on Processing Capital Expenditures

Mine Mouth Revenue

Alberta Pre-Payout Royalty: 1% of mine mouth revenue.

Cash Flow Format for Post-Payout Royalty: applies after payout occurs.

Gross Revenue
- Allowed Capital Costs
- Operating Costs
- On-Site Exploration and Development Costs

Revenue for Processing Allowance
- Processing Allowance
- Operating Losses from Prior Years
- Off-Site Exploration Costs

if negative, Carried Loss for Next Year
if positive, Net Revenue

Alberta (continued)

Allowed Capital Costs: permits 100% write down of allowed capital expenditures in the year of acquisition. Included in this category is an allowance for indirect capital costs of 1% of the capital costs incurred.

Processing Allowance: 10% per year of the original cost of processing assets but not to be more than 65% of the revenue for processing allowance.

Operating Losses: may be carried forward until recovered. The calculation of an operating loss excludes royalty paid.

Off-Site Exploration Costs: incurred in Alberta before the commencement of mining operations.

Alberta Post-Payout Royalty: the greater of 1% of mine mouth revenue or 12% of net revenue.

British Columbia

Cash Flow Format:

Revenue
- Operating Cost

Net Income before Allowances
- Depreciation Allowance
- Interest Payments
- Exploration Expenditures

Income for Earned Depletion Allowance
- Earned Depletion Allowance

Income for Processing Allowance
- Processing Allowance

Income for British Columbia Mining Tax
British Columbia Mining Tax

Depreciation Allowance: applies to all capital costs. Calculated in the same manner as explained under 'capital cost allowance' and 'development expenditures' for federal corporate income tax.

Earned Depletion Allowance: calculated in the same manner as explained for federal corporate income tax.

British Columbia (continued)

Processing Allowance: 8% per year of the original cost of processing assets but not to be less than 15% nor more than 50% of income for processing allowance.

British Columbia Mining Tax: 17.5% of income for mining tax.

Note: all allowances must be taken on an individual project basis.

Northwest Territories

Cash Flow Format:

Revenue
- Operating Cost

Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

Income for Processing Allowance
- Processing Allowance

Income for Northwest Territories Mining Tax
Northwest Territories Mining Tax

Depreciation Allowance: all capital costs except post-production mine development capital costs allowable at 15% per year on a straight-line basis; post-production mine development capital costs at 100%.

Processing Allowance: 8% per year of the original cost of processing assets but not to be less than 15% nor more than 65% of the income for processing allowance.

Northwest Territories Mining Tax:

income for mining tax	marginal rate
up to 10,000	exempt
10,000 - 1 million	3%
1 million - 5 million	5%
5 million - 10 million	6%
10 million and over	+ 1% for each additional $5 million up to 12% maximum

Yukon Territory

Cash Flow Format:

Revenue
- Operating Cost

Net Income before Allowances
- Depreciation Allowance
- Exploration Expenditures

Income for Yukon Mining Tax
Yukon Mining Tax

Depreciation Allowance: all capital costs except post-production mine development capital costs allowable at 15% per year on a straight-line basis; post-production mine development capital costs at 100%.

Yukon Mining Tax:

income for mining tax	marginal rate
up to 10,000	exempt
10,000 - 1 million	3%
1 million to 10 million	5%
5 million - 10 million	6%
10 million and over	+ 1% for each additional $5 million up to 12% maximum

Rates Used to Calculate Tax Credits Associated with Exploration Expenditures

Newfoundland	66.0%	
Nova Scotia	64.0%	
New Brunswick	73.7%	(allows for special exploration write-off)
Quebec	57.5%	
Ontario	63.7%	(allows for percentage depletion in Ontario corporate income tax)
Manitoba	69.0%	
Saskatchewan	63.5%	
Alberta	57.0%	
British Columbia	65.6%	
Northwest Territory	50.0%	(assumes 6% mining tax rate)
Yukon Territory	50.0%	(assumes 6% mining tax rate)

Weighted Averages

Appalachian Region	65.7%
Canada	61.5%

THE AUTHORS

Brian Mackenzie is a senior research associate of the Centre for Resource Studies and a professor in the Department of Geological Sciences at Queen's University. He received his formal education in mining engineering and mineral economics at McGill University, the University of the Witwatersrand, and Columbia University. In his early years, he worked for Sheep Creek Mines, Union Corporation, the South African Department of Mines, and Energy, Mines and Resources Canada. From 1968 to 1977 he was responsible for teaching and research in mineral economics and was director of the mining program at McGill University. He joined Queen's University in 1978. Dr. Mackenzie has carried out a wide range of assignments on mineral policy and planning issues for mining companies, governments, and international agencies. In 1977 he was named distinguished lecturer in mineral economics by the Canadian Institute of Mining and Metallurgy, and in 1983 he received their "Robert Elver Mineral Economics Award". He has presented mineral economics seminars in Canada, Australia, Brazil, Chile, China, Finland, Greece, Indonesia, South Africa, Sweden, Tanzania, and the United States.

Michel Bilodeau was born in Montreal in 1948. He graduated in 1970 from Ecole Polytechniqué with a bachelor's degree in geological engineering. He then received the degrees of M.Sc. (App.) in mineral exploration and Ph.D. in mineral economics from McGill University. Dr. Bilodeau is an associate professor in the Department of Mining and Metallurgical Engineering at McGill University. He is also a faculty associate of the Centre for Resource Studies. Dr. Bilodeau specializes in quantitative methods of analysis, computer modelling, geostatistics, and mineral economics.

Michael Doggett is a research associate of the Centre for Resource Studies at Queen's University. He holds a B.Sc. (honours) in geology from Mount Allison University and an M.Sc. in mineral economics from Queen's University where he is currently enroled in a Ph.D. program. His background includes mineral exploration in Canada and Australia as well as extensive research into the economics of gold mining in Canada. Present interests and research focus on the costs and benefits associated with the global emphasis on exploration and development of gold deposits.

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